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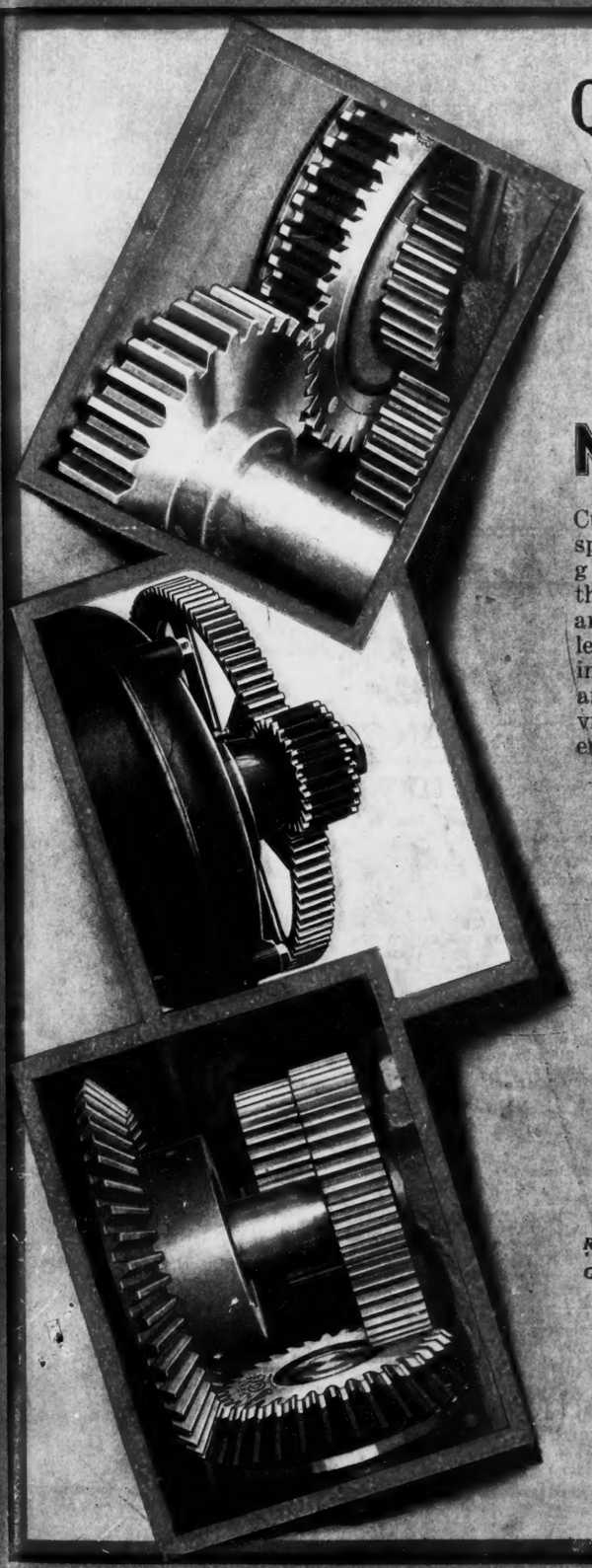

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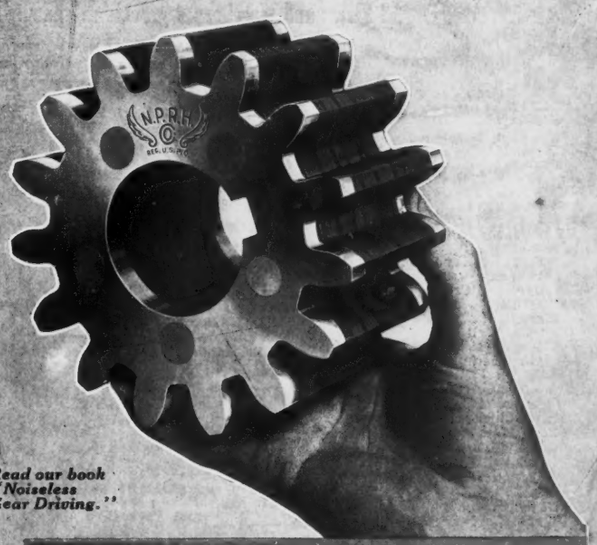

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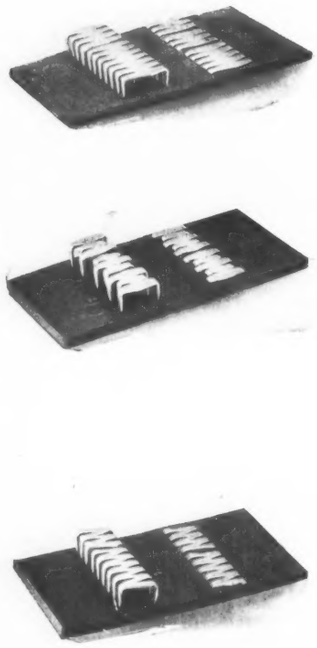

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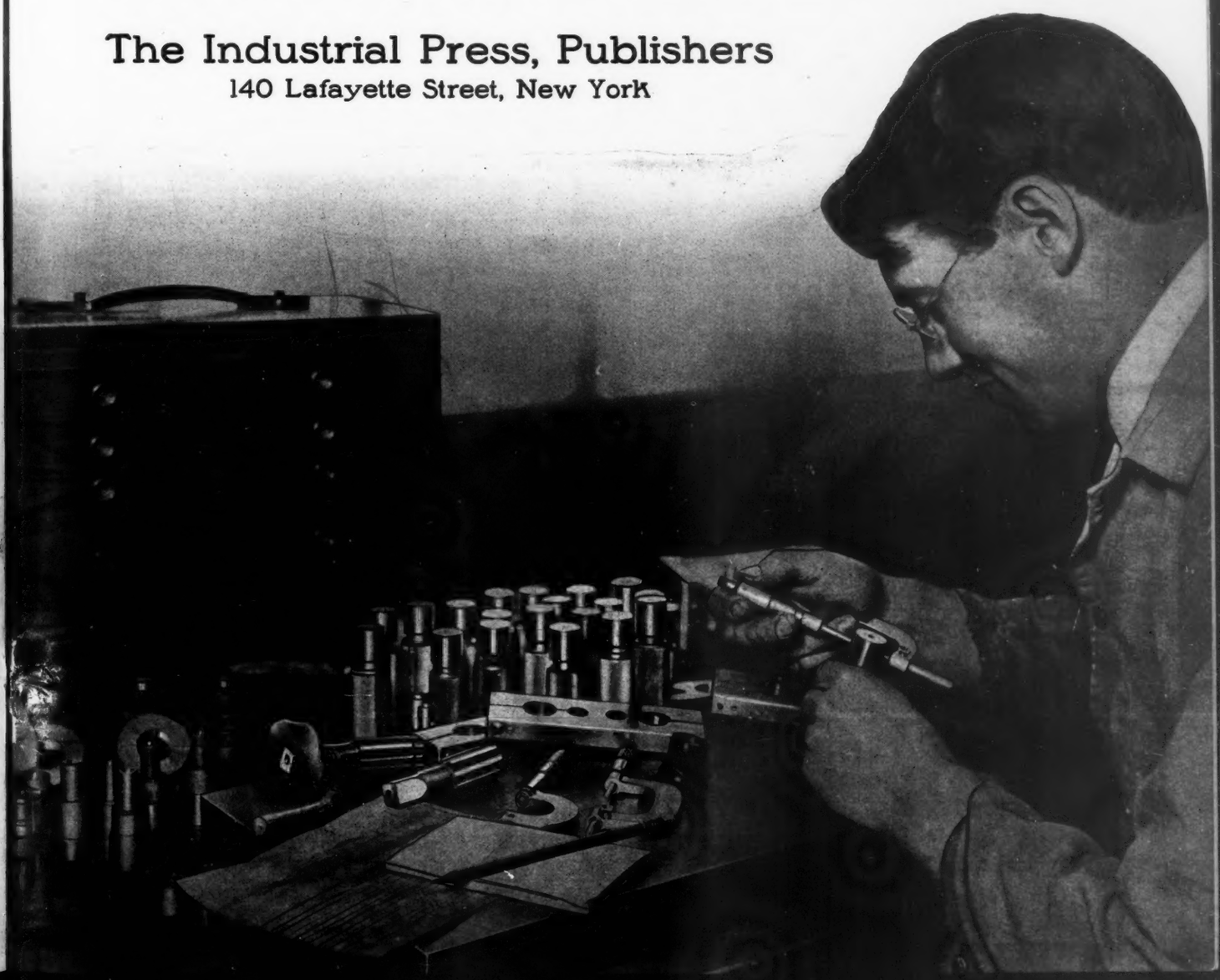

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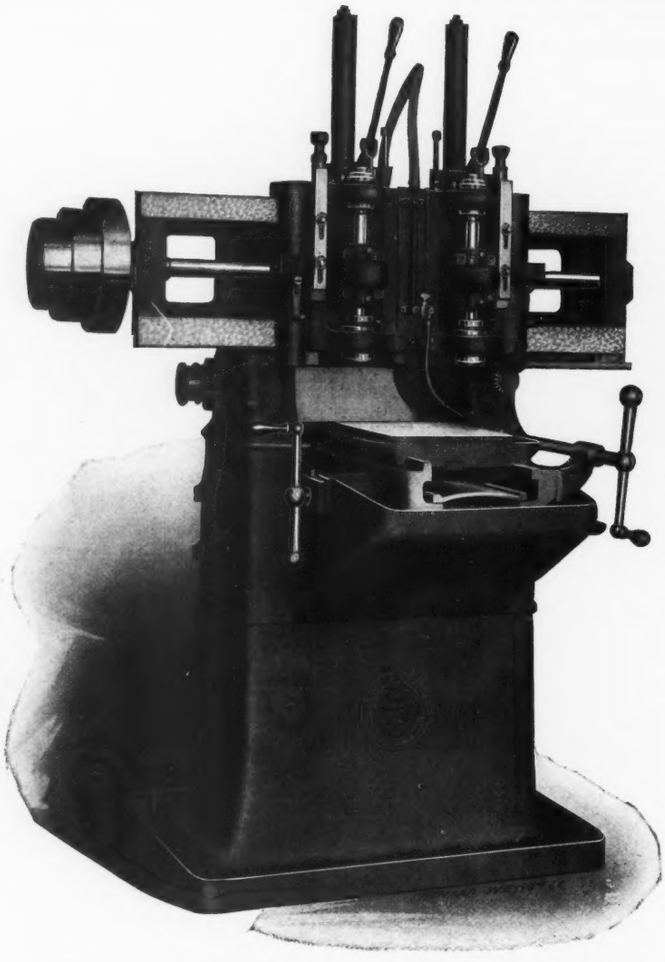

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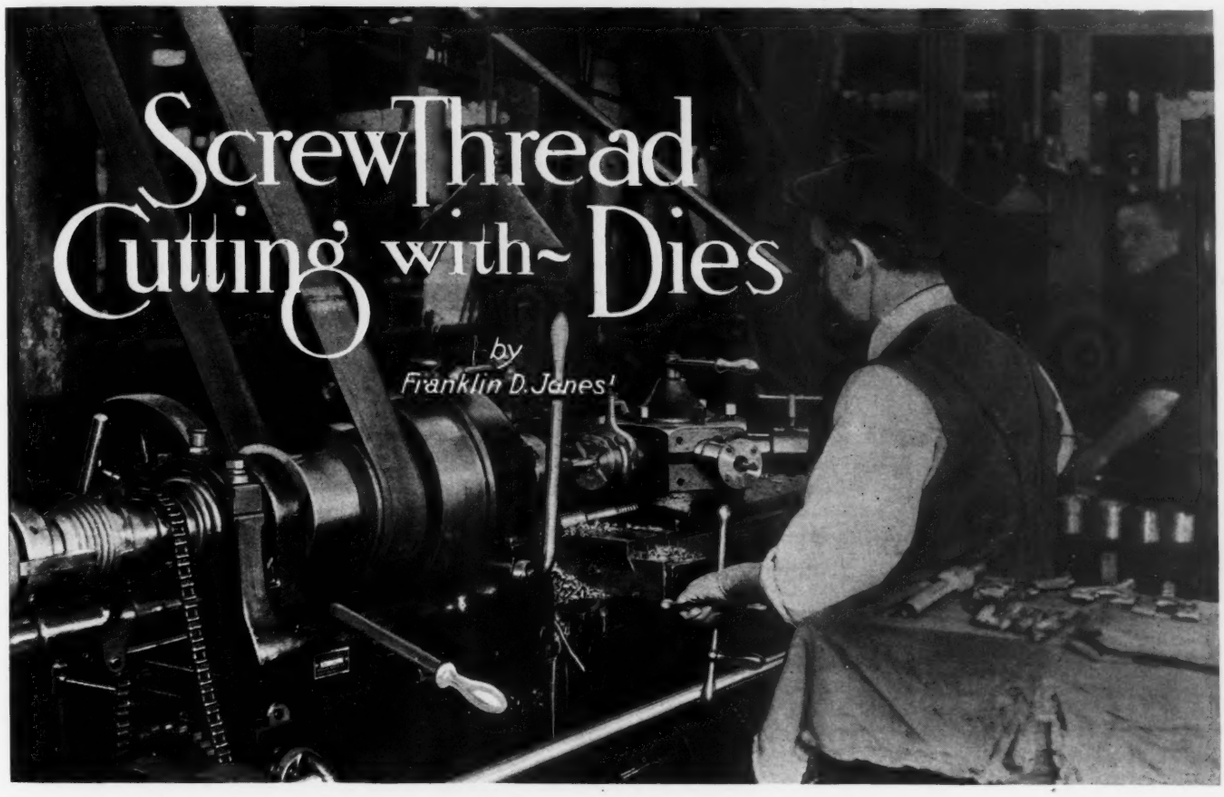
Screw Thread Cutting with Dies

by Franklin D. Jones[1]



This is the beginning of a series of articles dealing with the design, operation, and application of various classes of standard and special tools, machines, and attachments used in producing screw threads. The general subject of thread-cutting dies is covered in this installment, which includes various types of dies, principles governing their operation and maintenance, and the causes of common defects in die-cut threads.

THE formation of accurate and interchangeable screw threads on a commercial or manufacturing basis has been a difficult proposition in many machine shops. The extent of the difficulties encountered in connection with this work may depend largely upon the meaning of that indefinite term "accurate" and also upon the length of time that is allowed for the screw-cutting operation. On many classes of threading work the degree of accuracy, combined with the speed of production demanded, makes screw cutting a troublesome operation, and even when the conditions are not unusually severe, the production of smooth, correctly formed threads requires tools that are properly made and applied. While some equipment is incapable of producing good screw threads, regardless of the time that might be expended (either because it was poorly constructed to begin with or is in bad condition), many notable improvements have been made in screw-thread forming tools and methods, and in this general review of the subject the more important types of tools or machines for producing screw threads will be described. In this particular article, which deals especially with threading dies, and in other succeeding articles, those features that have a direct bearing on the accuracy of screw threads and the speed of production will be considered, as well as the relative merits of different types of tools or machines and the general classes of work for which they are adapted.

General Methods of Forming Screw Threads

The two general methods of forming screw threads may be defined as the cutting method and the rolling or impression method. Some of the various modifications of these two general methods will be outlined. The cutting methods as applied to external threads are briefly as follows:

1. By taking a number of successive cuts with a single-point tool that is traversed along the part to be threaded at a rate per revolution of the work depending upon the lead of the thread. (Common method of cutting screw threads in the engine lathe.)
2. By taking successive cuts with a multiple-point tool or chaser of the type used to some extent in conjunction with the engine lathe and on lathes of the Fox or monitor types.
3. By using a tool of the die class, which usually has four or more multiple-point cutting edges or chasers and generally finishes the thread in one cut or passage of the tool.
4. By a single rotating milling cutter, which forms the thread groove as either the cutter or work is traversed axially at a rate depending upon the thread lead.
5. By a multiple rotating milling cutter which completes a thread in approximately one revolution of the work.

When screw threads are produced by the rolling or impression method there are two general processes:

1. By rolling the blank in contact with a revolvable disk or roll, the periphery of which has either a single thread or a multiple thread corresponding in pitch to the thread required.
2. By rolling the blank in contact with flat dies having parallel ridges which are spaced in accordance with the required pitch and which form the screw thread.

Internal screw threads, or those in holes, may or may not be produced by the same general method that is applied to external work. There are three commercial methods of importance, namely:

1. By the use of a single-point traversing tool in the engine lathe or a multiple-point chaser in some cases.
2. By means of a tap which, in machine tapping, usually finishes the thread in one cut or passage of the tool.
3. By a rotating milling cutter of either the single or multiple type.

Controlling Motion of Thread-forming Tool

The general methods of controlling the motion of a thread-forming tool relative to the work, for generating thread grooves of helical or "spiral" form, vary according to the type of tool or machine used for the screw-cutting operation. Considering, first, the action of the tool while cutting a thread groove, there are three general methods of securing the necessary motion:

1. The tool-holder or carriage (or the work in some cases) is traversed by a lead-screw driven by gearing of such a ratio that the relative motion of the tool per revolution of the work is equal to the lead of the screw thread required.

[1] Associate Editor of MACHINERY.

2. The motion is obtained by the direct action of a lead-screw, which is not driven through gearing and has a lead equal to that required on the part to be threaded.

3. The tool when in the form of a tap or die may be self-propelling or self-leading, the tool moving each revolution a distance equal to the thread lead as the result of its screwing action, caused by the location of the cutting teeth along a helical path.

After a thread-cutting tool has completed a cut, it is usually necessary to return it to the starting point either for the purpose of taking another cut (as when using a single-point tool) or for removing the tool from the work (as when withdrawing a tap or die from the threaded part). This return movement may be obtained by the following methods:

1. By a hand or power traversing movement of the tool carriage or holder in the direction of the axis of the work, after withdrawing the cutting tool or tools for clearing the screw thread.

2. By reversing the rotation of the work- or tool-spindle for backing a non-collapsing tap out of a hole or for unscrewing a non-opening die from the threaded part.

3. By running a tap or die at a slower speed than the work while cutting the thread and then at a faster speed for unscrewing the thread-cutting tool.

When a thread is being formed by the rolling process, the tool, if of circular shape, simply moves at right angles to the axis of the work for bringing the roll into contact with the part to be threaded and for removing it after the thread has been formed. In the case of flat thread rolling dies, the blank to be threaded is rolled between a stationary die and a movable die having a reciprocating motion.

Selection of Thread-forming Method

One of the most important questions relating to the formation of screw threads is the particular method that should be employed for a certain class of work. What is the most rapid method of performing the screw-cutting operation without sacrificing the necessary accuracy? That is the question that has often puzzled shop foremen and superintendents and one that is not answered in the same way by those who have studied the problem of screw thread production. Variations of practice in different shops are often due to the fact that the equipment at hand is used not because it is considered the best, but because there is no choice. In other words, the amount of money appropriated for new tools is often the real reason why different types of tools are used for the same general classes of work. While each class or type of thread-forming tool or machine has a definite field, in some cases these fields overlap, and then judgment, experience and records of past performance must be utilized in deciding what method is to be employed.

Among the important factors that affect the thread-forming methods may be mentioned the diameter of the screw, pitch of thread, degree of accuracy necessary, number of parts to be threaded, location of thread, material of which parts are made, and relation of threading operation to other work which may precede or follow it. It will be understood that no inflexible rule can be given as a guide and that the different factors mentioned may be combined in various ways, thus changing the problem partly or entirely. Other conditions

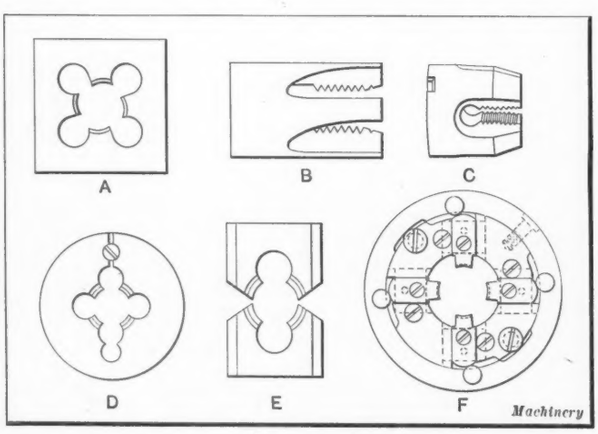


Fig. 1. Different Types of Threading Dies

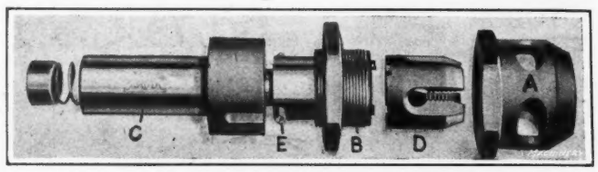


Fig. 2. Acorn Die and Die-holder

peculiar to any one job may also have a decided effect on the exact method of procedure. This matter of selecting equipment for the production of screw threads involves not only a study of the different classes of work for which various types of tools are adapted, but a careful investigation into the performance of different makes of tools of the same class or type. The difference in the quality of tools of the same class accounts for many variations of opinion. One man contends that a certain type of tap or die is incapable of accurate work, but, if the truth were known, the general type may be entirely satisfactory when properly made or applied. This is also true of thread-forming tools of other classes. In dealing with the various types of thread-forming equipment, the kind of work and the particular advantages of each type will be enumerated in as specific a manner as seems practicable. Unfortunately, however, it is not possible to deal with this question of selecting thread-forming tools in such a definite way that instructions may be followed to the letter and without the assistance of experience and judgment.

General Application of Threading Dies

Most external screw threads are cut by means of dies, because tools of this class not only cut threads very rapidly, but when properly made are capable of producing screws that meet most commercial requirements as to accuracy. It is impossible to enumerate all the classes of work for which dies are used; however, they are applied in general to the threading of a large percentage of the small and medium-sized screw threads, ranging from the smallest screws, bolts and studs up to heavy screws four or five inches in diameter, or larger in some cases. These die-cut screw threads include those of the rougher grades represented by ordinary studs, bolts, etc., and also a great deal of the more accurate work on machine parts generally.

Work of the stud and bolt class is almost invariably threaded by means of dies, but the application of dies to the better grades of screw thread cutting depends upon conditions. For instance, dies are ordinarily used on turret lathes and semi-automatic or automatic screw machines for external threading operations, because they provide an efficient method not only of forming a screw thread, but also of doing it without removing the work from the machine. On the contrary, dies are rarely used on the engine lathe, which has its own screw-cutting mechanism and is designed primarily for a wide range of work rather than for manufacturing duplicate parts in quantity like the turret lathe and automatic screw machine. In some instances, the use of dies on the turret lathe or screw machine is not practicable, as, for example, when there is a shoulder between the surface to be threaded and the turret.

While there is no well-defined line showing just where the practical application of dies ends, there are certain limiting factors which should be considered. In general, as the pitch of the thread and its diameter increases beyond certain limits, the use of dies decreases. Dies may be employed for cutting threads of coarse pitch, but, ordinarily, the lathe or a thread milling machine is used in preference. Whether or not a die could be used to advantage might depend upon the type of machine employed for the other operations, such as turning, etc., and the number of pieces to be threaded or the degree of accuracy necessary. In the manufacture of pipe, dies are used for cutting the threads even on the large sizes, because they provide a rapid means of doing the work and the pitches of the threads are fine in proportion to their diameter. The large dies used for pipe threading or other operations are, of course, quite costly and can only be employed to advantage when the quantity of work warrants the necessary investment.

Dies are efficient as a means of cutting screw threads, because they usually finish the thread complete in one cut, although two passes or cuts are desirable for certain classes of work, some dies being arranged for taking a light finishing cut. When cutting threads of coarse pitch, considerable metal is removed in a short time, especially when a single cut is taken, and although these heavy cuts may be distributed between three or four teeth at the throat of the die, the difficulty of obtaining smooth, accurate screw threads increases for the larger pitches. Dies may be used for pitches up to one-quarter or one-third inch, or even larger, but die threading operations of this kind are not common. When dies are used for cutting screws of coarse pitch and of relatively small diameter, the torsional or twisting strain on the work and the resulting impairment of the accuracy of the screw may be so great that the use of a lathe or thread milling machine is preferable, if not necessary.

When making any comparison on the basis of accuracy between screw threads cut with dies or by means of a lathe or thread milling machine, it is important to remember that there are "dies and dies." In general, a well constructed lathe or thread milling machine will cut a thread that is more accurate as to form and lead than a high-grade die, for the following reasons: In the first place, a carefully ground single-point tool or single type milling cutter is more accurate than a multiple-point die chaser or cutting edge, which must be correct both as to the form of each tooth and the pitch of the teeth; second, a die which is self-leading and not positively controlled by a lead-screw is less likely to produce a thread of accurate lead than a single-point tool or a rotating milling cutter that derives its motion directly from an accurate screw. There is a difference, however, in the self-leading qualities of different dies. Some of the important causes of inaccuracy in the lead of die-cut threads will be considered later. The difference in accuracy between the best grade of die work and the product of the lathe or thread milling machine is usually so small as to be negligible for most commercial work, which, in conjunction with the speed of dies as a means of screw cutting, accounts for the extensive application of dies in all machine building plants.

Types of Non-opening Dies

Dies may be divided into two general classes, namely, those that are removed from the screw thread by being backed off or unscrewed, and those that may be opened so that the cutting edges clear the screw thread, thus permitting the die to be removed by traversing it over the work in a lengthwise direction. The non-opening dies are capable in some cases of hand adjustment, but the object of this adjustment is to vary the size of the die, so far as machine threading operations are concerned. There are four types of non-opening dies in common use, which may be designated as (1) solid dies, or those that are rigid and incapable of any adjustment for varying the diameter; (2) flexible dies, or those that are split in one or more places and may be adjusted to some extent by compressing or expanding; (3) sectional dies, or those formed of two adjustable sections; (4) rigid adjustable dies of the chaser type, having inserted chasers that may be adjusted radially within certain limits either for maintaining a standard size or for varying the size slightly.

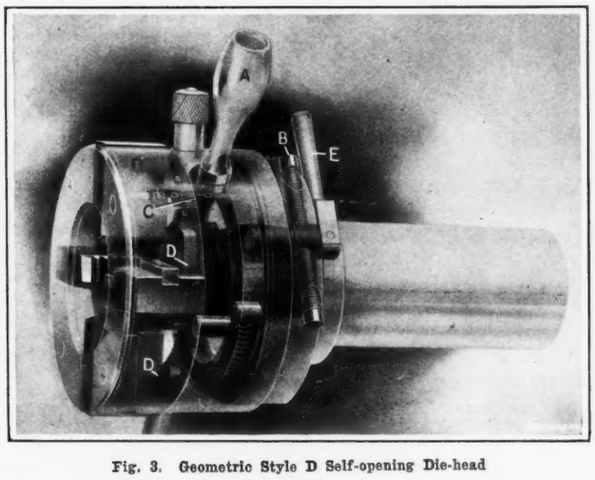


Fig. 3. Geometric Style D Self-opening Die-head

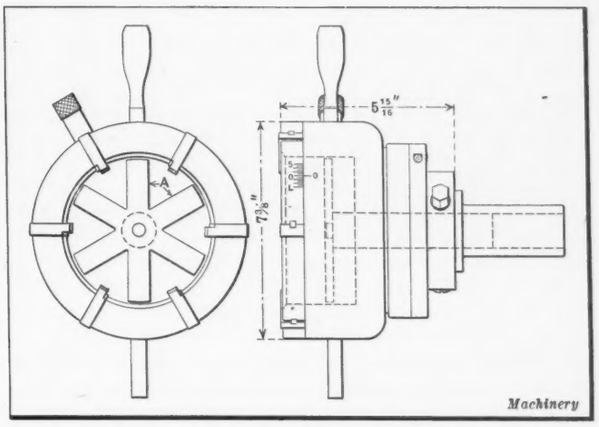


Fig. 4. Self-opening Die-head of Internal Trip Type

A common form of solid die is shown at *A*, Fig. 1. This form is used for some bolt and pipe threading operations and for the rougher classes of screw cutting. The accuracy of the die is likely to be impaired considerably by hardening, and there is no means of reducing the diameter as it gradually increases on account of wear. Most solid dies of the rigid class are square on the outside, although some are round or of hexagonal shape. The latter are similar to a nut except that they have flutes on the inside to form cutting teeth and are made of hardened steel. Dies of this kind are used principally for repair work, as they are easily turned with a wrench and are convenient for truing or recutting battered threads.

The split dies, or those having enough flexibility to permit adjustment, are made in different shapes, the three common forms being the spring screw die shown at *B*, the "acorn" die *C*, and the round split die *D*, which is sometimes known as a button die. A great many spring screw threading dies are used on automatic screw machines for cutting the smaller sizes of screws. The die has four projections or prongs on which the cutting edges are formed. These prongs are quite flexible and must be held in position when the die is in use by some form of external ring or clamp. Many of these clamping rings are split on one side, and the split ends are joined by a screw which provides adjustment for closing in the cutting edges to the required size. This type of clamp is objectionable in that it does not compress the different prongs uniformly, so that the work of cutting the thread is not properly distributed between the cutting edges. One method of overcoming this difficulty is to use a solid ring that is slightly tapering on the inside to fit a corresponding taper on the outer surfaces of the die prongs. The collet style of holder for spring screw dies is a further improvement, as it is in the form of an external sleeve completely surrounding the die, and not only holds it rigidly, but provides a convenient means of uniform adjustment for variations in size. The teeth of these dies may be cut with either a straight hob or from the back with a hob that is slightly tapering. When a straight hob is used it is a few thousandths over size, the amount depending upon the pitch of the thread; the prongs of the die are afterward forced in to the correct size by the clamp collar or chuck. This adjustment produces a slight inaccuracy in the thread, and for that reason it is preferable to use a tapering hob to obtain the necessary clearance, the die being cut to the correct size at the point and not over size, as when a straight hob is used. This back taper varies from 0.005 to 0.010 inch per inch for iron and steel, and from 0.008 to 0.015 inch per inch for dies employed for cutting threads on brass. One of the great advantages of the spring screw die as compared with the round split form shown at *D* is that the radial cutting edges can easily be reground when they become dull by using an ordinary dished wheel, the beveled edge of which is inserted in the flutes of the die. With the round split form, a special grinding wheel is required.

The lands or cutting ends of the acorn die *C* are shorter and wider than those of a spring die, which increases their strength against torsional or twisting strains. The part of each land or prong just back of the cutting teeth is made comparatively thin to give the necessary flexibility for radial adjustment. The form of holder used in connection with this die (as manufactured by the Greenfield Tap & Die Corporation, Greenfield, Mass.) is illustrated in Fig. 2. The die *D* is contained within an adjustable cap *A*, which is screwed onto section *B* of the die-holder. The outer end of each die prong is beveled to fit a corresponding conical surface on the inside of the adjusting cap *A*. The base of the die, which is ground true, bears against the end of the floating part *B* of the die-holder and has notches which engage short driving pins. The connection between part *B* and shank *C* is obtained through a cross-pin *E*, which engages the slots shown in the illustration. This arrangement is, of course, to provide a certain amount of floating movement. Radial adjustment of the lands for varying the size of the die is obtained by simply turning the adjustable cap *A* in one direction or the other after loosening the locking nut. The adjustment derived in this way, by means of the internal conical surface referred to, serves to move each of the four lands an equal amount radially, so that the work of cutting a screw thread is evenly distributed. The acorn die, like a spring die, may readily be resharpened on the radial faces, the grinding being done in the flute, the same as with a spring die.

Round split or button dies (one form of which is shown at *D*, Fig. 1) are used principally on turret lathes and hand and

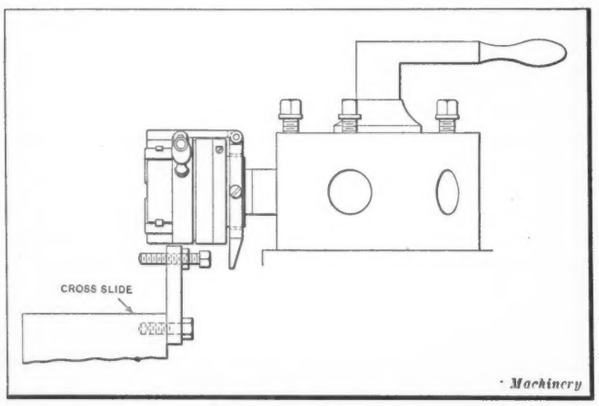


Fig. 5. Self-opening Die-head of Outside Lever Trip Type and Adjustable Stop for controlling Point at which Die trips or opens

automatic screw machines; they are applied to the same general classes of work as spring screw threading dies. The button dies are more rigid than the spring dies, if the latter are adjusted by the usual ring or clamp, but, as previously mentioned, they are not so easily sharpened on the radial cutting faces. The initial cost of the button die, however, is less than that of a spring die and the former is not distorted as much in hardening.

The sectional type of die formed of two separate parts (*E*, Fig. 1) is extensively used in die-stocks for hand threading operations on bolts, pipe, etc., and also in some power-driven screw-cutting machines. The outside shape of these dies varies. The form shown has sides with a double bevel to give the two die sections a tight grip in the holder and permit reversing the position of the die for cutting close to a shoulder. Some dies of the two-piece form are round and are used in preference to the kind shown at *D*, which is split on one side only. The advantages claimed for this type are that it does not lose its shape the same as a die which springs together on one side only, and it can be more easily ground.

The rigid adjustable die of the chaser type (*F*, Fig. 1) provides a convenient means of adjusting the die either to compensate for the wear of the chasers and maintain a standard size or to vary the diameter slightly from the standard. This general type has several advantages when applied to operations for which it is especially adapted. For cutting comparatively large screw threads, the chaser type of die is preferable

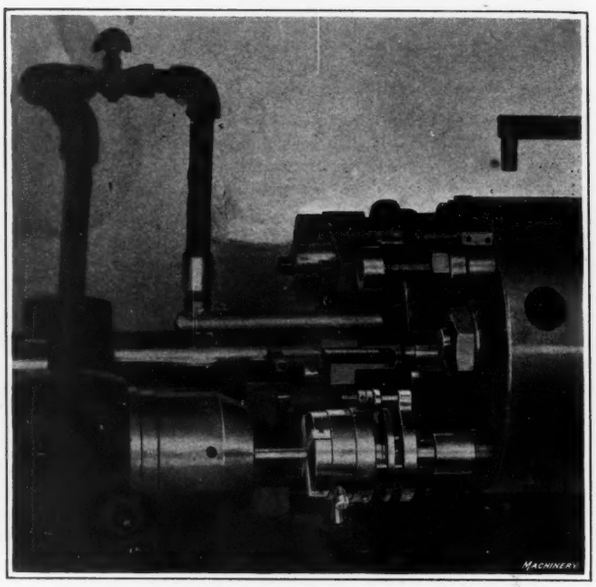


Fig. 6. Geometric Style DD Self-opening Die-head on a Cleveland Automatic

to a solid split or spring die, partly because it is capable of more accurate work. The one-piece die is always subject to distortion in hardening, especially when made in large sizes. The use of inserted chasers is also an advantage, because a practically new die may be obtained by inserting a new set of chasers, when, as a result of repeated grinding and wear, this becomes necessary; the body of the die may be used permanently. Dies of the adjustable chaser type may be used in preference to the automatic or self-opening class (to be described later) for cutting screw threads that are so short that the time saved by the opening dies is too small to offset the difference in cost. The adjustable chaser design, in general, is also more rigid than the self-opening die and better adapted for taking heavy cuts on threads of coarse pitch when the thread is to be finished by a single cut. The construction of these dies varies considerably. The particular design shown at *F* (the "Namco") has four chasers, which are held firmly over plates in the body by screws and dowel-pins. They are supported laterally or at the sides by hardened eccentric binding screws and are backed up at the ends by hardened pins carried by a heavy adjusting ring. A loose or tight fit may be obtained with a set of chasers by means of an adjusting screw which changes the position of the adjusting ring and pins relative to the oval-backed chasers.

Removal of Non-opening Dies from Work

After a screw thread has been cut with a non-opening die, the latter is removed by unscrewing or backing it off the

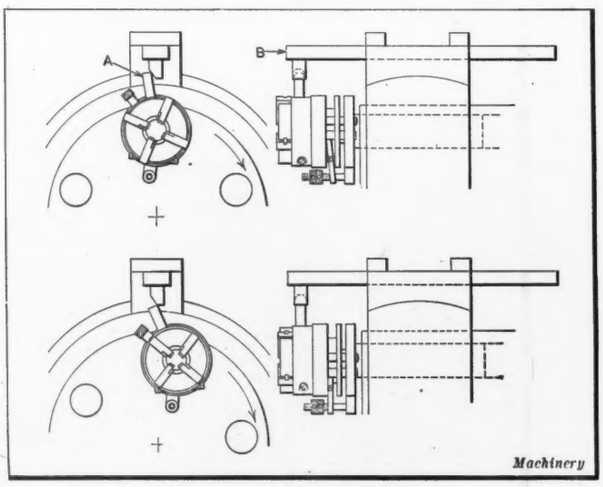


Fig. 7. Closing Attachment for Self-opening Die-heads applied to a Cleveland Automatic

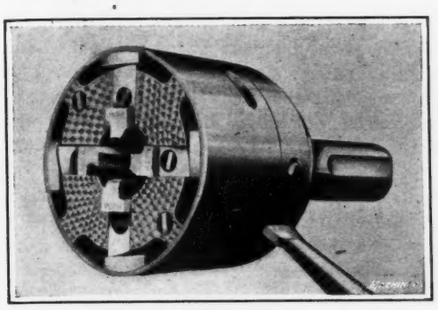


Fig. 8. "Namco" Self-opening Die-head of Non-revolving Type

threaded section, unless, as is sometimes the case, the part being threaded passes clear through the die. The latter method is sometimes followed when a vertical spindle machine like a drill press is used for threading plugs or other parts by screwing them down through a die attached to the table; the finished work then simply falls through the die. The same method has been employed in threading taps. It is especially applicable when there is a square end on the work, or opening, to provide a convenient means of driving by simply engaging the parts with a socket or other form of driver on the spindle that readily releases after the work has passed through the die. While this method of cutting screw threads has been utilized to some extent, in most cases it is necessary to back off a non-opening die, and this may be done in three different ways: (1) the rotation of the work may be reversed after the thread is cut; (2) the die itself may be reversed, thus unscrewing it from the threaded part; (3) the die may be revolved in the same direction as the work but at a somewhat slower rate of speed while cutting the thread and then at a faster rate so that the die backs off the threaded part while it still continues to revolve in the same direction as the part being operated upon. This third method is employed on some automatic screw machines.

Application of Self-opening Dies

The automatic or self-opening type of die represents one of the most important developments in thread-cutting tools. There are two serious objections to the non-opening die: One is that time is wasted while the die is backing off the threaded part. The other and often more serious objection, especially when threading tough material, is that the threads are frequently marred, if not spoiled entirely, by the backward movement of the die. This roughing or tearing of the thread is due to the fact that when either the die or the work reverses there are chips left in front of the cutting edges especially at the throat of the die; consequently, as the die moves back these chips or others previously removed often become wedged between the lands of the die and the screw and roughen the thread or tear it as the die is being removed. Trouble of this kind may often be greatly reduced or practically eliminated by using dies having a minimum amount of relief. The roughness of the thread may also be due primarily to other causes. For instance, some grades of soft "stringy" steel are difficult to thread smoothly. In such a case, the only remedy is to use a steel higher in carbon or if a good grade of material is not necessary a steel higher in phosphorus and sulphur. The roughness of a thread may be, and often is, due to the use of die chasers which are not properly made or ground. Unscrewing the die, however, has caused much trouble, and defects from this source may be avoided by the use of self-opening dies. The latter may also increase the speed of thread-cutting operations 30 or 40 per cent, by reason of the rapid removal of the self-opening type after the thread is cut. The additional complication necessary in a self-opening die means a higher initial cost which is sometimes to be considered when the amount of work is relatively small.

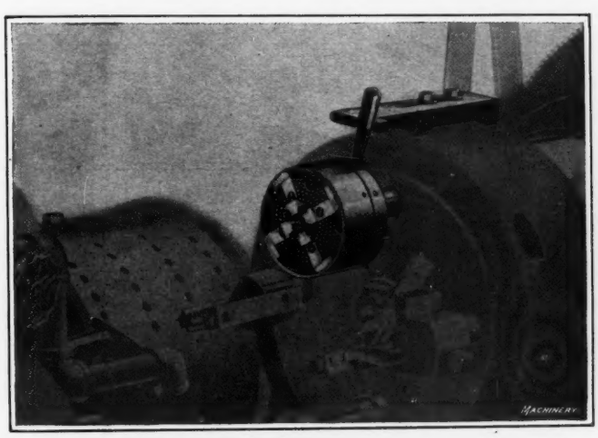


Fig. 9. "Namco" Self-opening Die-head on a Cleveland Automatic, showing Closing Device

An automatic die is, as a general proposition, less rigid than a non-opening die such as the inserted-chaser type, especially after the parts have become worn. It is for this reason that some self-opening dies will not cut a satisfactory short thread, especially if the length of the thread is about equal to the width of the die chasers. The chasers spring outward somewhat at the beginning of the cut and make the thread tapering. This error may be so small as to be negligible when a good die is used, and, in any case, screws having a length equal to several times the die-chaser width will be cut straight except for a few threads at the beginning and end of the screw, where there may be an appreciable amount of taper. Another difficulty that has been experienced with some self-opening dies is in the accumulation of chips in the die-head, which interferes with the action of the movable members and increases the amount of wear; much has been accomplished, however, in the design of self-opening dies toward keeping the die-head free from chips that impair its effectiveness and also in rigidly supporting the chasers so that outward radial thrusts are taken directly by solid parts of the die.

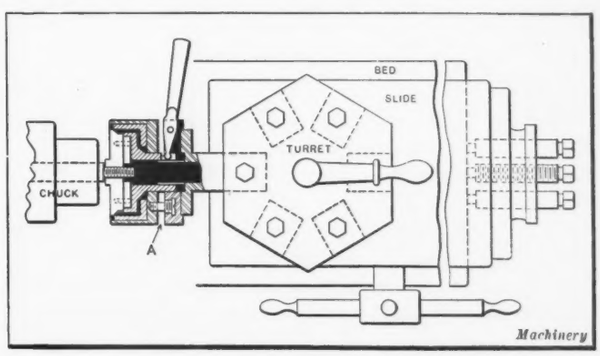


Fig. 10. Diagram illustrating Method of adjusting Turret Slide Stop for a "Namco" Self-opening Die-head

The relative merits of self-opening dies and the solid or non-opening type, may depend upon the length of thread to be cut, the type of machine, its reversing speed, and the number of parts to be threaded.

Types of Self-opening Dies

The different designs of automatic or self-opening dies differ principally in regard to the mechanism for opening the die chasers at the completion of a cut, the method of closing the chasers to the cutting position after removing the die, and the method of supporting the chasers against radial thrusts. Self-opening dies, in general, are formed of two main sections. One section, which includes the shank and inner part of the die body, is attached to the turret, spindle or other part of the machine. These two main sections have a certain relative motion for opening the die or releasing the chasers from the work and for closing the chasers to the working position. This motion for operating the die may either be parallel to the axis of the die, rotary, or helical. The radial motion of the chasers for opening or closing the die is commonly derived or controlled either from cam surfaces or the conical surface of a sleeve in contact with the chasers.

The three general methods of opening dies of this class automatically are by stopping the travel of the turret at a predetermined point; by the engagement of an outside tripping finger, latch, or lever on the die-head with a fixed stop or

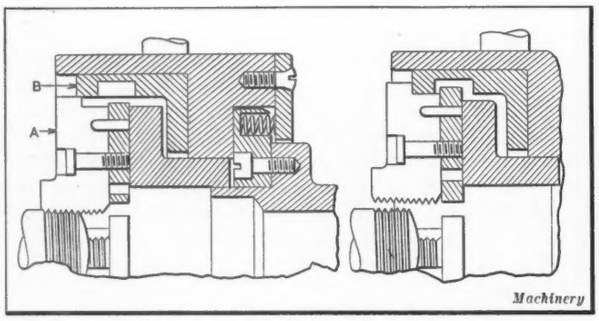


Fig. 11. Sectional Views of No. 11-22 Series "Namco" Self-opening Die-head showing Arrangement for obtaining Instantaneous Opening Action

plate; by the engagement of the end of the work with a tripping plate located inside the die. Most self-opening dies are of the non-revolving type, the die remaining stationary while the part to be threaded rotates. Dies of this class commonly have a hand-lever for opening or closing them. Some dies of the automatic class are designed to be revolved. Several commercial designs of self-opening dies will be described to illustrate the variations in construction and methods of operation.

Geometric Self-opening Dies

The standard design of Geometric self-opening and adjustable die (style D) shown in Fig. 3 is intended for use on hand-operated turret lathes and automatic screw machines. This die, made by the Geometric Tool Co., New Haven, Conn., is so arranged that it opens automatically as soon as the travel of the shank section of the die-head is retarded. When used on the turret lathe the stop-screw or rod of the turret

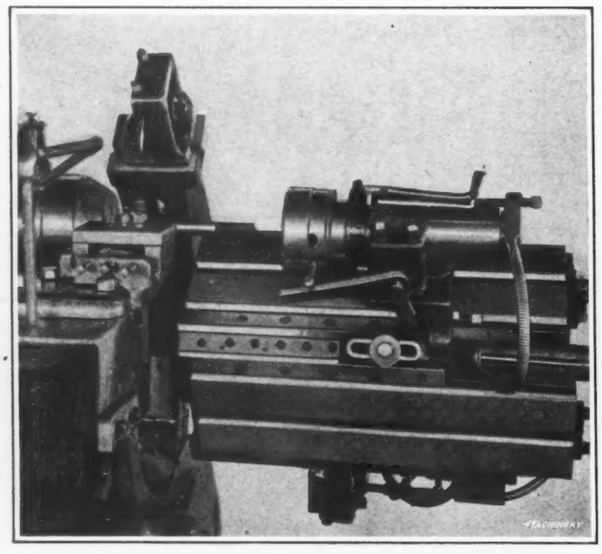


Fig. 12. Hartness Self-opening Die-head applied to a Gridley Automatic

slide may be set to stop the movement of the turret when the required length of thread has been cut. If desired the die can be opened at any intermediate point by simply holding back on the lever for operating the turret slide. The die chasers are closed to the working position after being opened, by handle *A* projecting from the side. The die may also be closed automatically by screwing a pin into a threaded hole opposite this handle and attaching a stop to the rear edge of the turret slide in such a position that it will engage the pin as the turret revolves. Slight variations in diameter (indicated by graduations at *C*) to secure a tight or loose fitting screw may be obtained by adjusting screws *B*. The radial movements of the die chasers for opening or closing the die are derived from cams *D* which engage slots in the chasers on the rear side. The chasers are held on splines at one side of the opening in which they are a close fit to prevent tilting due to the cutting strain. This style of die is made in sizes ranging from ⅛ inch to 4½ inches. The sizes over and including ¾ inch have an attachment which permits taking roughing and finishing cuts. When the small lever *E* is turned to a position opposite that shown in the illustration, the chasers are all moved outward 0.01 inch ready for the roughing cut. Returning this lever to the position shown closes and locks the chasers for the finishing cut.

A style C Geometric die of the inside trip type is shown in Fig. 4. This die has an internal adjustable gage or stop *A* which comes in contact with the end of the work, thus automatically opening the chasers. This type is preferable to the "pull" type (which trips after the turret slide stops) for certain classes of work and for some machines, as, for example,

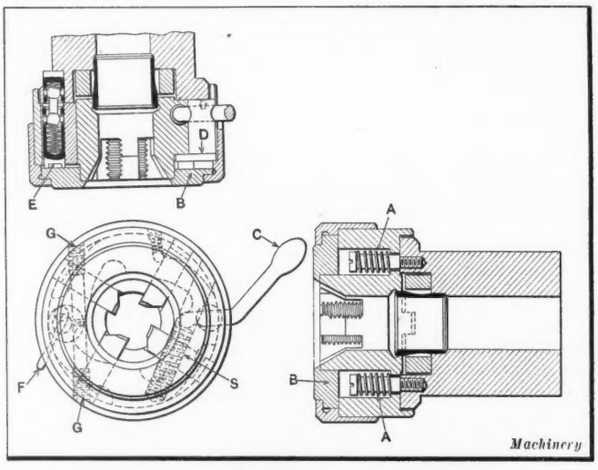


Fig. 13. Mechanism of Hartness No. 4 Automatic or Self-opening Die-head

where turret stop-screws or rods are not provided for every turret hole. Fig. 5 shows a style C Geometric die of the outside lever trip type. A fixed stop is attached to the cross-slide and it is provided with an adjustable screw for varying the point at which engagement with the tripping lever of the die occurs. The outside lever trip type is recommended for cutting short threads of fine pitch because the chasers are relieved of all strain when tripping.

A third style of Geometric die (style DD) is shown in Fig. 6 applied to a Cleveland automatic screw machine. This die was designed especially for use on the turret of the Cleveland machine, but it can be applied to other automatic or semi-automatic machines in which the operating requirements are practically the same. The die-head is supported by a spring mechanism between the head and shank which permits the chasers to align themselves with the work and compensate for any slight inaccuracy in turret adjustment. This floating connection also permits a certain amount of longitudinal movement independent of the motion of the turret slide so that the die is free to follow its own lead. After the turret slide stops its forward movement, the die-head has a slight independent movement which brings the lock-nuts seen in the side of

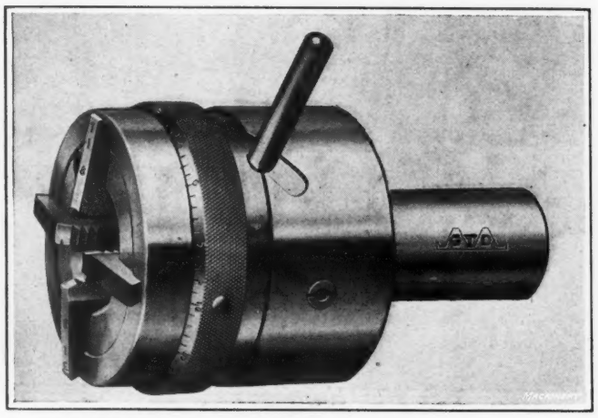


Fig. 14. Wells Self-opening Die-head of Model B Pull-trip Type

the die-head in contact with a hinged plate. The movement of this plate releases the locking bolt and allows the chasers to open or move outward. The point at which the die opens may be varied slightly by adjusting these lock-nuts. The illustration shows the die at the point where the tripping mechanism is about to operate, the lock-nut having come into contact with the tripping plate.

The arrangement for closing the die-head automatically is illustrated in Fig. 7. A closing pin *A* is attached to the die-head, and mounted above the turret there is a closing bar *B* having a beveled pin which projects downward. After a thread is cut by the die, the latter is carried around as the turret indexes until the closing bar comes into contact with the pin on the die. The upper view shows the die-head just at the point of closing and the lower view illustrates how the die is turned part of a revolution for closing as the turret indexes.

"Namco" Self-opening Dies

A "Namco" self-opening die of the non-revolving type is shown in Fig. 8, and applied to a Cleveland automatic screw machine in Fig. 9. This is another die of the type that opens when the turret slide reaches the end of its travel. When the forward movement of the slide is discontinued, further rotation of the screw thread draws the die-head forward, thus releasing the chasers from their bearing on the cam ring arms and allowing them to spring open. The die is closed by the lever seen projecting from the side which serves to draw the body back into the hood, thus bringing the chasers into contact with the cam ring arms. Whatever variations in diameter may be required are obtained by a sensitive adjusting screw in the side of the die-head. The hand-lever may be operated automatically by the rotation of the turret, as when the die is used on an automatic screw machine. The closing device shown in Fig. 9, consists of a projecting plate or arm having an inclined edge over which the closing lever slides as the die is indexed past this point. The form and location of this closing attachment varies more or less for different machines.

When the die is used on the turret lathe the general method of adjusting the turret slide stop for controlling the operation of the die is as illustrated by the plan view, Fig. 10. After the die is attached to the turret, the first thread is cut to the required length and the machine stopped with the die chasers still engaged with the thread, the chasers being closed. The turret slide stop is next adjusted until the slide moves backward sufficiently to take up the lost motion or longitudinal float at *A* in the die-head, and the die chasers spring open. Another trial screw thread is then cut, and if the length of the thread must be exact a slight further adjustment may be necessary. The method of arresting the feeding movement of the turret varies on different machines.

The "Namco" die-heads do not have a cover or plate in front, but are left open; one reason for this construction is to permit a free flow of oil through the die-head to flush or wash out the chips so that the die will be self-cleaning. Some "Namco" die-heads (the No. 11-22 series) are designed especially for cutting very short threads or those of ordinary lengths right up to a shoulder if necessary. The die-head is designed to open the chasers instantaneously at a given point. The top or outer ends of the chasers are not beveled as in the dies previously referred to, but have square shoulders instead, as shown by the sectional view, Fig. 11. The bearing arms *B* of the cam ring rest on the top of these shoulders until the chasers *A* are pulled forward at the end of the cut by the action of the screw thread; the arms of the cam ring then drop down into the lower shoulders, as shown by the view to the right, thus allowing the chasers to fly outward instantly, in order to prevent interference with a shoulder on the work.

The revolving type of "Namco" self-opening dies is designed for use on the Acme automatic multiple-spindle screw machine, on bolt and stud threaders, and other machines in which the work is held stationary while the die is revolved, or, in cases where both the work and die rotate. The opening and closing of the chasers is effected by the longitudinal motion of the hood relative to the body of the die, the same as with the designs previously referred to. The floating style of revolving die-head is designed for threading parts that are not finished from the bar at one setting but are chucked

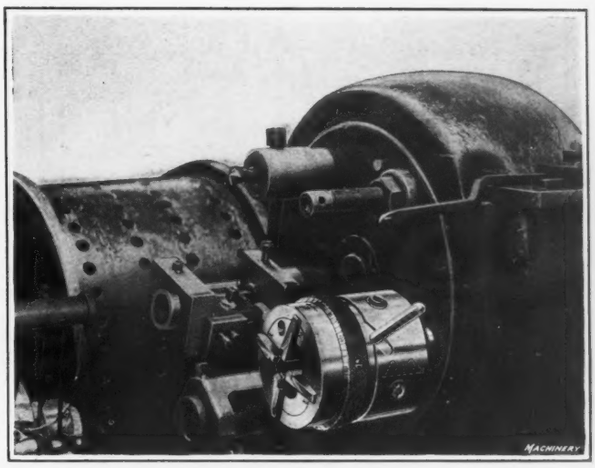


Fig. 16. Wells Self-opening Die-head applied to a Cleveland Automatic

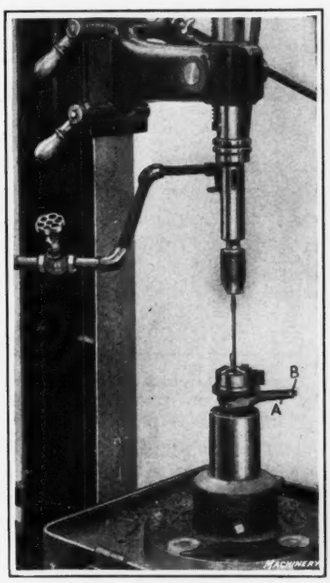


Fig. 17. Thread Cutting on a Drilling Machine with Stationary Self-opening Die

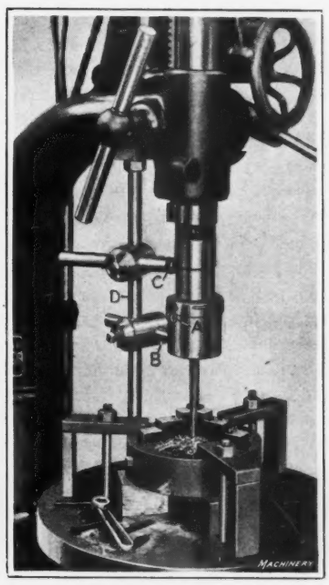


Fig. 18. Drilling Machine equipped with Revolving Type of Self-opening Die

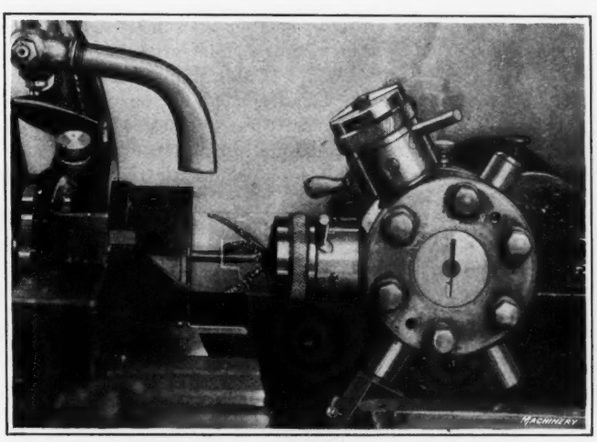


Fig. 15. Two Wells Self-opening Die-heads for taking Roughing and Finishing Cuts on a Brown & Sharpe Automatic Screw Machine

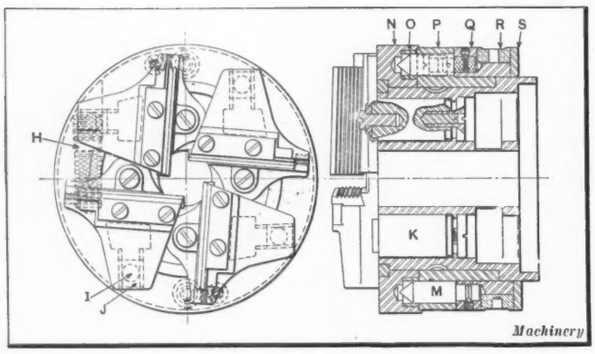


Fig. 19. Landis Rotary Die-head

either by hand or from a magazine for the threading operation. This floating mechanism compensates for any variation in alignment between the work and die-spindle. The "Namco" dies are made by the National Acme Co., Cleveland, Ohio.

Hartness Automatic Die

A Hartness automatic or self-opening die is shown applied to a Gridley automatic in Fig. 12, and in section in Fig. 13. The construction of these dies varies somewhat for different sizes, although they operate on the same general principle. The description applies to the No. 4 size shown in Fig. 13. The die body is held to the shank by screws *A* and the springs around them. An equalizing collar provides the driving connection between the body and the shank and allows the body with its chasers to float and thus center itself relative to the action of the work. The chasers are held in position in radial slots in the body and their movements are controlled by cam ring *B*. By throwing over the locking lever *C* against the pressure of the main springs the cam crank *D* and the cam ring are turned, thus closing the chasers. The cam ring is held in the closed position by the latch pin *E*, which has two engaging surfaces for locking the cam ring. One of these surfaces is regularly used for taking the finishing cut. If the material is hard or the pitch coarse enough to require two cuts, the roughing handle *F* is thrown over, so that another surface on the latch pin is utilized and holds the chasers in position for the roughing cut. After roughing out the screw thread, the chasers are set for the finishing cut

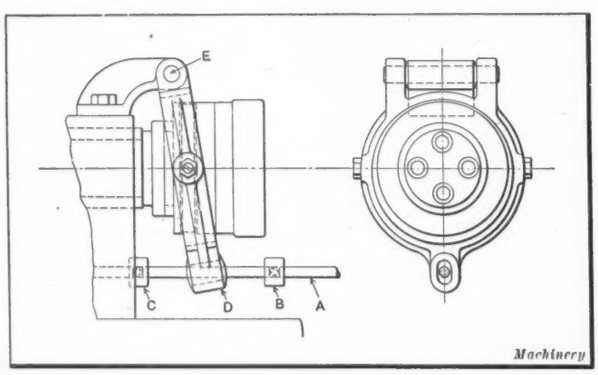


Fig. 20. Mechanism for opening and closing Landis Rotary Die-head

by simply throwing handle *F* back to its original position. The latch pin is contained in an eccentric sleeve, which may be turned to vary the position of the cam ring for adjusting the radial location of the chasers and the finished size of the work. The size-adjusting screws *G* are used for making this change. The two cuts (roughing and finishing) are seldom required for threads smaller than one inch in diameter and 12 pitch, but are intended to be used for coarse pitches and on materials that are especially hard and tough. The largest of the Hartness dies (the No. 9) has three separate adjustments, so that two roughing cuts and a finishing cut may be taken if necessary, without disturbing the adjustment for the final or finishing size. Fig. 12 illustrates one method of closing the die automatically. A pin projecting from the side of the die engages the inclined plate shown. This self-closing feature varies, of course, on different makes of machines, so far as its exact arrangement is concerned. The automatic opening of the die occurs whenever the feeding movement of the tool-slide discontinues. The die-head travels forward a short distance before opening, after the tool-slide has stopped. These dies are manufactured by the Jones & Lamson Machine Co., Springfield, Vt.

Wells Self-opening Dies

The Wells self-opening die, manufactured by the Greenfield Tap & Die Corporation, Greenfield, Mass., is made in three models. Model B, intended for general use on turret lathes, automatic screw machines, etc., is shown in Fig. 14. This model is a pull-trip design, the chasers opening automatically after the advancing movement of the turret slide is discontinued. The chasers are held in slots in the body of the die, and are supported near the rear end by hinge pins, which serve as fulcrums for the opening and closing action. A

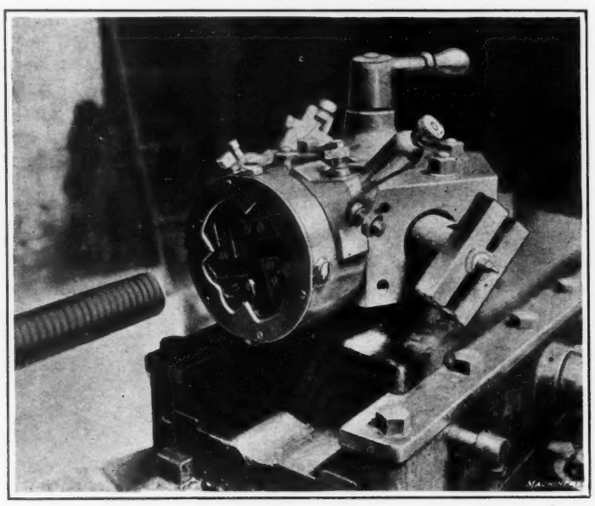


Fig. 21. Landis Automatic Self-opening Die applied to Turret Lathe

spring-actuated plunger bears against the short rear ends of the chasers, forcing the front ends of the chasers outward against an external sleeve or shell. This shell has a beveled surface on the inside which bears against a corresponding bevel on the back of the chasers and furnishes a firm backing or support directly back of the cutting teeth. This outer shell slides in a lengthwise direction on the inner body of the die, permitting the chasers to open as it slides back and closing them as it is pushed forward. In action, as soon as the turret slide stops, the die is automatically tripped by a specially shaped shoulder on the trip screw engaging with the latch. The opening action is as described in the preceding. The die is closed by the handle or pin, which projects from the side, coming in contact with a stop, where it is latched in position ready for the next cut. Slight diameter adjustments for making the thread either larger or smaller than the standard diameter are made by turning a knurled and graduated ring.

Fig. 15 illustrates two Model B dies, applied to a Brown & Sharpe automatic screw machine. This is particularly fine work where a specially finished thread is desired; one of the dies is used to take the roughing cut and the other the finishing cut. These dies are closed automatically by the rotation of the turret, the closing handles on the dies coming into contact with a stationary spring finger or other form of fixed stop. The operation of the same type of die on a Cleve-

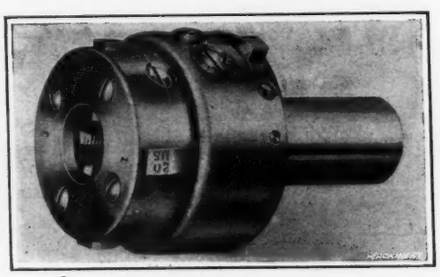


Fig. 22. H. & G. Revolving Self-opening Die-head

land automatic is shown in Fig. 16. The die just described has in some measure replaced the Model V, which is shown on a drilling machine in Fig. 17. This is not a typical application, however, as this design is used more generally on hand-operated screw machines or turret lathes. This is the simplest form of any of the three models. It is opened automatically by the engagement of a latch projecting from the face of the die with the work-holding chuck or some form of stop that may be attached to the machine. The hand-lever on the die is intended for operating it when setting up the machine. A twist of the cross-bar at the top of the lever releases the latch, permitting the die to open.

Drilling machines are often used for thread cutting when this is the only operation and it is not convenient to use another type of machine. The revolving or "rim trip" type of Wells self-opening die, Model T, is intended for application on such machines as drill presses, bolt cutters, multiple-spindle screw machines, etc. This die, which is shown applied to a vertical-spindle drilling machine in Fig. 18, is tripped or opened by a ball shaped latch *A*, which projects through an opening in the side of the die shell or body. This model is closed by a yoke pushing the outer shell forward, or it can be closed by a stop bearing upon one side only. As arranged in Fig. 18, stop *B* trips the die when latch *A* has descended far enough to strike it. When the spindle is raised, stop *C*, which carries a roller at its end, engages the upper end of the sliding shell and holds it stationary while the die body is pulled up far enough for the trip latch to drop into place. These stops may be adjusted on the vertical rod *D* for varying the tripping and closing points in accordance with the length of screw thread. This die is adjusted by turning a small screw in the die face, which changes the position of the stop for the tripping latch. The chasers are the same as those in the other models, and their position in the body and opening and closing motion are exactly the same. Models B and V are equipped with or without a floating shank, permitting the die to advance upon the work according to the lead of the chasers and independently of the travel of the turret slide.

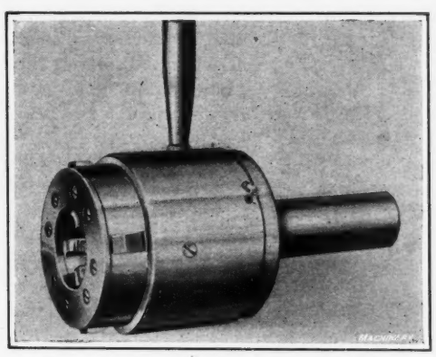


Fig. 23. H. & G. Hand-closing Die-head

Landis Self-opening or Rotary Die-head

The die-head illustrated in Fig. 19 differs from any of those previously referred to partly in that the chasers are set in a tangential position relative to the work instead of in a radial position. This particular design is designated by the manufacturer (Landis Machine Co., Inc., Waynesboro, Pa.) as the "rotary die-head," and has been used extensively on threading machines of the bolt cutter type. The general method of operating the die is indicated by the diagram Fig. 20. Rod *A* is attached to the slide or carriage that holds the work. This rod carries two adjustable collars *B* and *C*, which control the action of the die. The yoke ring *D*, which is pivoted at *E*, transmits motion to the die for opening and closing it. The die is opened when collar *B* engages the yoke ring at the completion of the thread-cutting operation, and it is closed when the carriage is returned to the starting point, thus bringing collar *C* into engagement with the yoke ring. The diametral adjustment of this die is obtained by means of an adjusting worm *H* (see Fig. 19), which is located in adjusting ring *P*. This worm engages the body of the die-head and moves closing ring *N*, adjusting ring *P*, operating ring *Q*, and retaining ring *S* as a unit. Graduations on the rear of the die-head indicate the position or adjustment for different diameters. Any adjustment is retained by means of a lock-nut. Two closing pins *M*, located diametrically opposite each other, are fastened at their rear ends to operating ring *Q*. The cylindrical portions of these pins pass through adjusting ring *P* and enter two hardened bushings *O*, which prevents relative motion of the closing ring with the rest of the die-head, except through the adjusting worm *H*. Closing ring *N* is subjected to pressure exerted by four springs. When yoke ring *R* is moved backward by engagement with the collar previously referred to, it transmits motion to operating ring *Q* and pins *M*. As this movement continues, the conical ends of the closing pins *M* engage beveled surfaces on bushings *O*, and closing ring *N*, because of the spring pressure, turns relative to the die-head body and opens the die. On the front face of closing ring *N* there are four pins *I*. These pins carry the blocks *J*, which impart the rotary motion of the closing ring to the chaser holders. Most of the cutting strain is taken by the large trunnions *K*, to which the chaser holders are securely fastened. As the closing ring rotates, the holders turn with their trunnions and open simultaneously. The conical points of the closing pins *M* are prevented from leaving the hardened bushings *O* by stop-screws in operating ring *Q*. The chasers are backed up at the rear and advanced in the holders by abutting screws, the correct cutting position being determined by means of a small hook gage. These chasers are sharpened by simply grinding the ends. By using right- and left-hand holders the same chasers may be employed for cutting right- and left-hand screw threads. The Landis "automatic" self-opening die, Fig. 21, is intended more especially for application to screw machines, turret lathes, etc., and is arranged to open when the forward motion of the turret is stopped. The continued pull of the work disengages the latch, and coiled springs within the head pull the four tangential chasers out of engagement with the work.

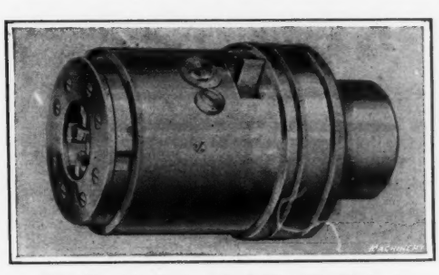


Fig. 24. H. & G. "Ford Special" Die-head

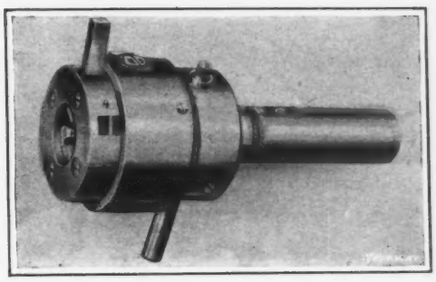


Fig. 25. H. & G. Automatic Self-opening Die-head

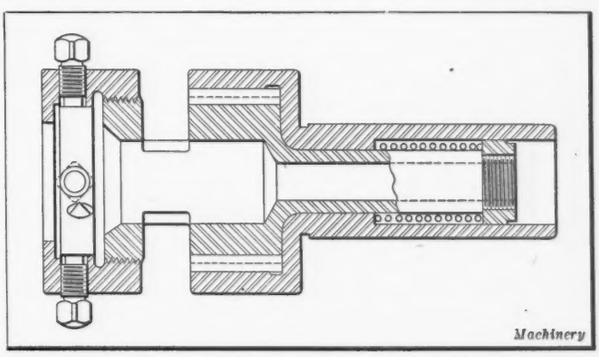


Fig. 26. Brown & Sharpe Die-holder of Non-releasing Type

H. & G. Self-opening Dies

The self-opening dies made by the Eastern Machine Screw Corporation, Truman and Barclay Sts., New Haven, Conn., are shown in Figs. 22 to 25, inclusive. The automatic self-opening die-head shown in Fig. 22 is used on National-Acme and Gridley automatic screw machines and other machines in which

the die-head revolves. All the parts of this head are interchangeable, there being as few as possible to obtain the desired result. The simplicity of the design gives durability and makes it improbable that the die-head will get out of order. A quick-release mechanism makes it possible to cut a thread right up to a given point and also up to a shoulder on the work; and the cams are all enclosed, so that chips cannot get in and clog the mechanism or cause the size of the threaded work to be changed. Support for the chasers is provided in such a way that it is impossible for them to be tilted and cut a tapered thread on the work. This die can easily be adjusted to suit the size of work by loosening a screw and moving a dial which is graduated to 0.001 inch. The chasers are removed by releasing a catch, and the head does not have to be taken apart. This die-head is of exceptionally small diameter and length for the size of work that can be threaded, thus making it especially adapted for use on automatic screw machines.

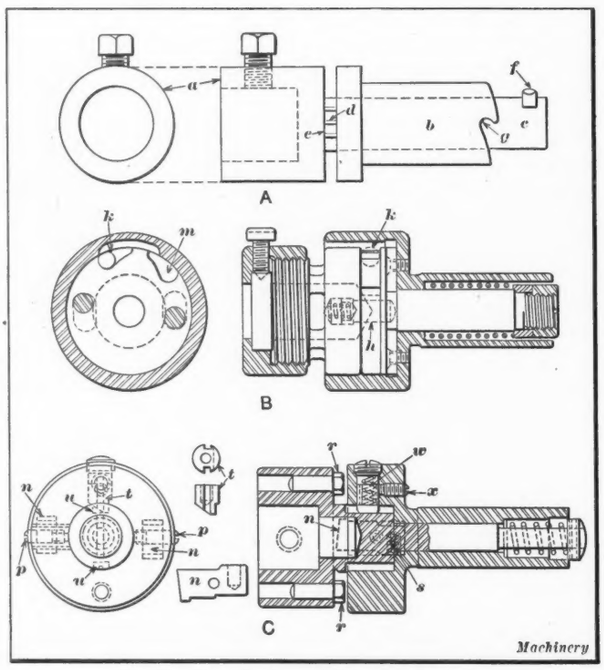


Fig. 27. Three Designs of Releasing Die-holders for holding Non-opening Dies

The automatic self-opening die-head shown in Fig. 25 is especially adapted for use on Brown & Sharpe automatic screw machines and other single-spindle screw machines. The lock is positive, so that a shock or jar of the turret cannot unlock the head. Closing is effected by a rotary cam, and takes place easily while the machine turret is revolving. The trip mechanism is positive and instantaneous in operation, thus allowing a thread to be cut close up to a shoulder or other specified point on the work. The chasers are held firmly, which insures the production of straight threads; and the head is furnished with a floating shank and compensating spring to assist in starting the thread. The chasers are made of high-speed steel and specially hardened.

The "Ford special" die-head shown in Fig. 24 works in a revolving position, and is especially adapted for use on threading machines. It is used on the automatic threading machine built by the E. J. Manville Machine Co., of Waterbury, Conn., and other machines of a similar type. This die-head is furnished with liberal adjustment and has large wearing surfaces to give durability. The hand-closing die-head shown in Fig. 23 is adapted for use on all turret machines. This die-head has a floating shank. The chasers are held in such a manner that the threads are sure to be straight.

Floating Movement for Die-holders

Die-holders for both non-opening and automatic dies may be arranged to hold the die rigidly or to permit either a longitudinal movement or a combined longitudinal and universal "floating" movement. Many of the die-holders used in connection with machine or power-driven threading operations allow the die a limited amount of motion in the direction of its axis, so that it will be free to follow its own lead and will not be retarded by a backward pull of the tool-slide to which it may be attached. For instance, when cutting a thread with a die in a hand-operated turret lathe, the turret slide is moved up until the die has started on the work. If the die-holder has longitudinal motion, the turret can lag behind somewhat without interfering with the forward motion of the die, which simply has to overcome the friction of the driving pins or keys of the die-holder as it screws itself onto the work. Of course, if the turret were not shifted along periodically when cutting a long screw, the lost motion in the holder would soon all be taken up and then the die would have to drag the turret slide. This extra load might seriously impair the finish and accuracy of the screw thread. When the machine is of the automatic type the cam operating the turret slide is generally designed to start the die on the work and then the slide is allowed to travel a little slower than the die that governs its own motion independently. If the cam were laid out to control the motion of the die positively, any variation between the motion of the die and the pitch of the chaser teeth would affect the thread being cut.

Some die-holders are arranged to give the die a free floating movement in a direction perpendicular to the axis, so that if the part to be threaded is not exactly in line with the die the latter can center itself relative to the axis of the work and cut a concentric thread on it. While every holder having the axial motion also has some lateral play, this is very slight in some holders and is a special feature in others. A lateral or universal float is especially desirable for dies used on parts that are chucked either by hand or from a magazine attachment for the threading operation. This floating motion is found on holders for both non-opening and self-opening dies.

The amount of longitudinal movement or float that a die-holder should have may depend upon the type of machine on

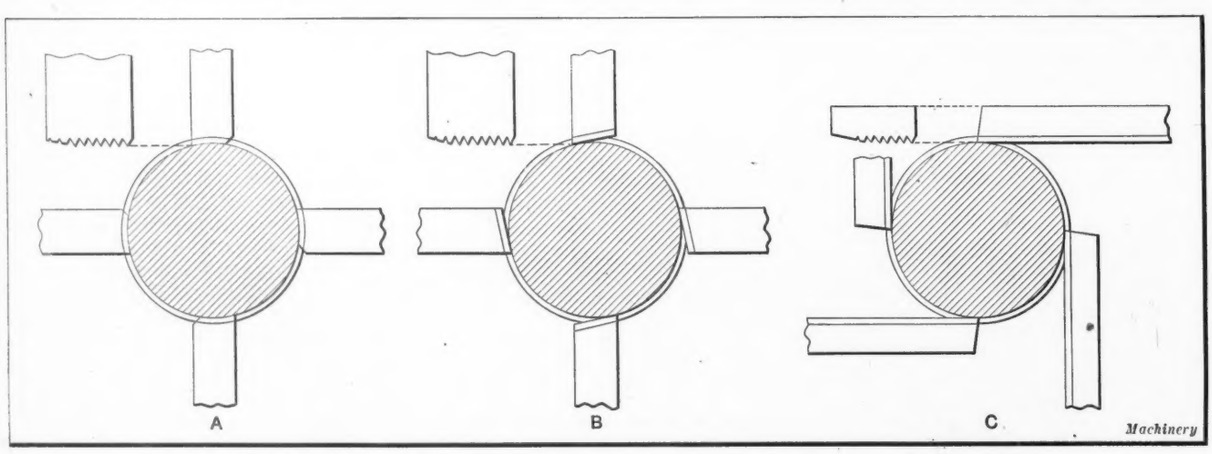


Fig. 28. (A) Hobbed Die Chasers. (B) Straight Milled Die Chasers. (C) Milled Chasers of Tangential Type

which it is used. If the die is used on a hand-operated screw machine or turret lathe, or a single-spindle automatic screw machine, the floating movement may not be over ¼ or ½ inch, the amount varying somewhat according to the size of the die-head. If the die is applied to a multiple-spindle automatic screw machine, considerably more floating movement may be necessary; in fact, the die, in some cases, may be attached to a telescoping sleeve arranged to give it a lengthwise movement of several inches, so that the die is enabled to move considerably in advance of other tools in the turret that may not have to move in so far from the end of the work.

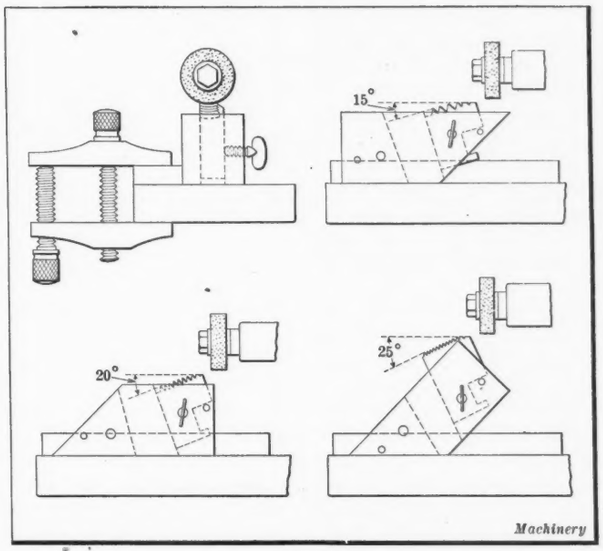


Fig. 29. Throat Angles for Chasers and Fixture for grinding

Releasing and Non-releasing Die-holders

The die-holders used for solid or non-opening dies may be of the rigid type, the floating non-releasing type, or the releasing type. For turret lathe and automatic screw machine work, the non-releasing type, which is free to move in a lengthwise direction a limited amount, is used extensively, although the releasing design is preferable under certain conditions. With this type the die is released or is not held against rotation after the thread has been cut to the required length. When the forward motion of the turret slide discontinues, the rotation of the screw thread draws one section of the die-holder farther forward until the driving connection between the two sections disengages; the die then continues to revolve with the work as long as the latter continues to run forward. When the spindle is reversed the die starts to rotate backward with it, but this reverse movement is stopped automatically by the die-holder, and the stationary die is then backed off the screw as the spindle continues its reverse rotation.

The releasing type of die-holder (which is intended only for non-opening dies) is used when it is necessary to govern closely the length of the thread, as, for example, when cutting a thread close to a shoulder. If the reversal of the machine is controlled by the operator, as in a hand screw machine, a releasing die-holder should be used, because, if the machine is not reversed at the instant a die of the non-opening type reaches the limit of its forward travel, the thread may be stripped or the die broken when attempting to cut close to a shoulder. When the releasing type of holder is applied to the threading spindle of a multiple-spindle automatic screw machine, if the the threading operation is completed before the other operations, the releasing device permits the die to revolve loosely until all the operations are completed.

The non-releasing type of die-holder is used for most of the thread cutting done on Brown & Sharpe automatic screw machines with non-opening dies. One design is shown in Fig. 26. The arrangement is such that the part to which the die is attached can move in a lengthwise direction relative to the shank. The releasing type is sometimes used to avoid having a narrow or pointed lobe on the cam controlling the thread-cutting operation. In some cases a cam that is laid out for the non-releasing type of holder has a thin, sharp threading lobe, but by substituting the releasing type a certain amount of dwell is obtained, so that the top of the cam lobe can be made wider.

Different Designs of Releasing Die-holders

A simple form of releasing holder is shown at *A*, in Fig. 27. The holder *a* has a shank *c* which passes through the sleeve *b*. This sleeve is held in the turret. When the die is cutting, the holder *a* is prevented from rotating with the work by the engagement of lugs *d* and *e*. When these lugs separate at the end of the cut, the die revolves with the work until the rotation is reversed; then pin *f*, as it revolves with shank *c*, engages notch *g* as the turret slide is returned, and stops further rotation of the die, which is backed off the threaded section.

The holder illustrated at *B* operates on the same general principle as the one just described, although the construction is quite different. The driving connection between the two main sections of the holder is through the pins *h*. When the turret slide stops and the die-holder is drawn forward, these pins *h* are disengaged, thus releasing the die. As soon as the work-spindle reverses, a ball *k* slides out of the deep part of the pocket in which it normally rests, thus locking the two main sections together while the die is being removed. The ball is inserted in pocket *m* when the die-holder is used for cutting left-hand threads.

The releasing die-holder shown at *C* is known by the manufacturer (the Cleveland Automatic Machine Co.) as the "silent" type, because the driving members are so arranged that they will not strike against each other after being disengaged. The main part of the die-holder, which is held in the turret, carries two bevel-ended driving lugs *n*, which are mounted upon pins *p*, so that they are free to swivel. These driving lugs engage pins *r* in the die-holder proper; when the latter is drawn forward at the end of the cut or after the turret slide stops moving, lugs *n*, acted upon by springs *s*, swivel until the beveled ends are practically in a plane at right angles to the axis of the holder. This swiveling movement provides clearance between lugs *n* and pins *r* so that the parts cannot strike against each other while the die is revolving with the work. When the spindle reverses, the beveled plunger *t* drops into slot *u* and holds the die stationary. This plunger is backed up by spring *w*. To change this die-holder for cutting left-hand threads, the driving lugs *n* are turned over, thus reversing the position of the straight driving side. The plunger *t*, which is held in position by the end of screw *x*, is also reversed.

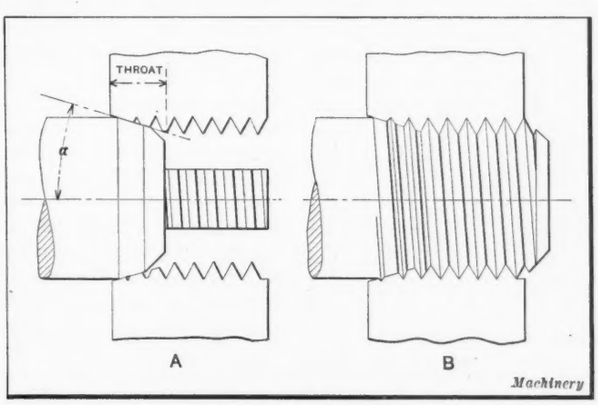


Fig. 30. Diagrams illustrating how Throat of Die serves to start Thread-cutting Operation gradually by distributing Work between Several Chaser Teeth

Chasers for Threading Dies—Forms of Teeth

The chasers used in screw-cutting dies vary in regard to the form of the teeth, the angles of the cutting faces or edges and the position relative to the axis of the die. The cutting qualities of a die and the accuracy of the screw threads produced by it may be affected greatly by the form of the teeth or the location of the cutting faces or edges of the chasers relative to the axis of the work.

There are three methods of forming the teeth of die chasers. One is with a hob

having helical-shaped cutting teeth. A second method is by using a milling cutter which has teeth perpendicular to the axis and is set to the helix angle of the screw thread when milling the teeth of a chaser. The cutter is fed across the chaser blank and forms a series of straight teeth corresponding in cross-section to the shape of the thread to be cut. The third method is by the use of a milling cutter like the one just referred to, with teeth which are at right angles to the axis (not helical), but which, after being set to the proper helix angle, is sunk into the ends of the chaser blank and forms teeth that are circular in a lengthwise direction instead of being straight.

The hobbed chasers represented by diagram *A*, Fig. 28, are formed by a tool which is similar to a tap, except that there are usually a greater number of flutes and cutting edges. The teeth are helical, corresponding to the threads of a screw, instead of being annular or at right angles to the axis. The chaser teeth formed by a hob are like sections on the thread of a nut, except that they are given a slight amount of relief or clearance back of the cutting edges. The clearance may be obtained by using a hob of the same size as the die and setting the chasers (which are held in a special fixture) a little off center while hobbing, or a hob that is somewhat smaller than the nominal size of die may be used to obtain clearance, especially when recutting the die chasers while they are held in the die-head. The "heel" or rear corner of each chaser is removed after hobbing by beveling it in as far as the center line to provide clearance. *B* shows milled chasers the teeth of which are straight, in a lengthwise direction, instead of curved. These teeth are formed by a cutter having teeth which are perpendicular to the axis, instead of being helical, and when milling the teeth the cutter is fed straight across the end of the chaser.

The chasers in the Hartness automatic dies are milled, but the teeth are circular, in a lengthwise direction, instead of being straight. According to the manufacturer, these chaser teeth are so formed that the front teeth form a cutting tool while the rear teeth form a lead-screw or act like the section of a nut on the threads formed by the leading side of the die. The milling cutter has teeth which are perpendicular to the axis and it is 2½ inches in diameter for all chasers, regardless of the pitch of the teeth or the diameter of the die in which they are to be used. The bearing of the chaser teeth on the finished thread is obtained by setting the cutter in such a position relative to the cutting edge of the chaser, when milling the teeth, that the full depth of the cut extends to the cutting edge only at the throat of the chaser. The reason given for avoiding contact with the work only at the cutting edges of the chaser teeth is that, when the chaser is made in this way, pressure in the direction of the axis of the screw causes the cutting edges to dig into the threads already cut, thus thinning them and changing the pitch of the thread. In order to prevent any such action, the rear chaser teeth on the Hartness dies are made to serve practically the same purpose as a nut, in order to steady the die and cause it to move forward at a uniform rate and in accordance with the lead of the thread being cut. It is also claimed that this feature has an important effect in producing clean, finely finished threads, as the chasers have a slight burnishing effect and impart a close grained surface to the thread.

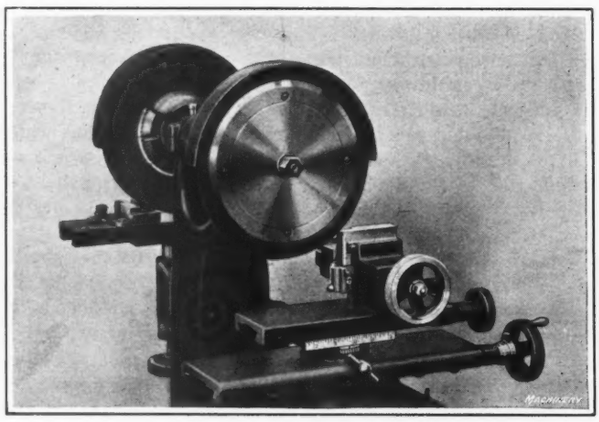


Fig. 33. Geometric Chaser Grinder set up for grinding Throat of Hobbed or Tap-formed Chaser

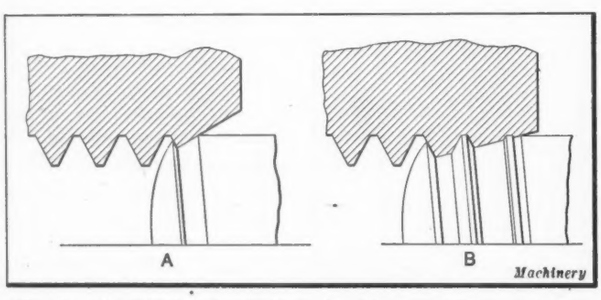


Fig. 31. (A) Throat that extends considerably beyond Roots of Chaser Teeth so that it is not Effective. (B) Throat that is Effective

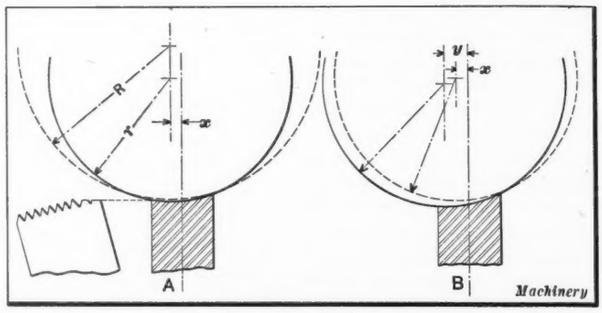


Fig. 32. Relative Relief obtained by varying Diameter of Grinding Wheel and Distance Wheel is offset from Center Line of Chaser

Still another form of milled chaser is illustrated at *C*. These chasers are the form used on the Landis die-head previously described) are set tangentially to the work. The milled teeth extend throughout the length of the chasers and they are in the form of straight parallel ridges corresponding in cross-section to the shape of the screw threads they are intended to cut. These chasers are sharpened by grinding on the ends, and as they become shorter as the result of repeated grinding, they are simply adjusted to the correct cutting position. The throat of the chaser and the front teeth shape the thread, while the rear teeth extend across the center line and take a bearing on the work just back of the cutting end of the tool. This is to make the four chasers act as a lead nut for controlling the forward movement of the die in accordance with the lead of the thread being cut.

Angle of Chaser Throat or Chamfer

The leading side or corner of each chaser in a die-head is usually beveled as shown in Figs. 28 and 30. This beveled edge is known as the "throat" of the chaser and serves to begin the cut gradually when the die is first starting a thread and also when it advances. At *A*, Fig. 30, is shown a chaser at the point of starting a cut, and *B* represents the position of the chaser after it has advanced far enough to begin forming a "full" or complete thread. The throat of the chaser not only inclines relative to the axis of the die (or screw being cut), but it is given clearance back of the cutting edge in a circumferential direction. In some cases the throat angle α must be abrupt in order to cut a full thread close to a shoulder. Aside from a requirement of this kind, the throat should preferably be ground so that the work of cutting a thread to the full depth is distributed over at least two or three teeth on the leading side of the die. It is common practice to grind the throat at such an angle that the beveled part extends from the root or base of the leading or most advanced tooth in the set of chasers back to the third tooth, which may be slightly beveled. The throats of some dies extend back over four, five or more teeth, although the shorter chamfer is more common. Each chaser should, of course, be ground to the same angle and so that each throat will be the same distance from the axis of the die when in the die-head.

The throat angles of chasers for the Hartness dies depend upon the pitch of the thread. The angles for different pitches

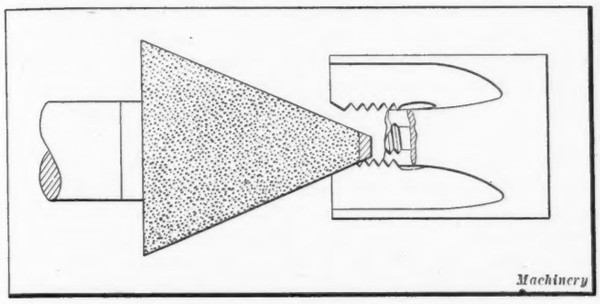


Fig. 34. Method of grinding Throat of Spring Die

are shown in Fig. 29, which also shows the type of fixture used for holding the chasers while grinding them. This fixture may be applied to different types of grinding machines by clamping a guiding strip to the grinder table, as indicated by the illustration. A throat angle of 15 degrees relative to the axis of the die is recommended for chasers intended for cutting threads varying from 4 to 5½ per inch. The angle of 20 degrees is intended for pitches varying from 6 to 8 per inch; and 25 degrees for pitches of 9 or more per inch. The object of decreasing the throat angle for the coarser pitches is to increase the length of the throat somewhat and distribute the work of cutting over more of the chaser teeth.

Die-chaser Throat that is Ineffective

A method of chamfering dies or die chasers that sometimes causes trouble is illustrated at *A*, Fig. 31. The die chaser may appear to have considerable chamfer, but when the relation between the throat of the die and the work is considered, it will be seen that there is little effective chamfer or throat. This is due to the fact that the beveled edge extends beyond or outside of the root or bottoms of the chaser teeth, where it cannot be effective when a screw thread is being cut; consequently the entire work of cutting the thread groove is imposed upon the leading tooth of each chaser. The chamfer, or throat, to be effective should begin near the root of the leading tooth (as indicated at *B*), so that it assists in the work of cutting the thread groove. If the die is held in a floating holder and the work is likely to be considerably out of line, the edges can be beveled beyond the root of the teeth somewhat, but this extra chamfer should not be considered as a part of the throat.

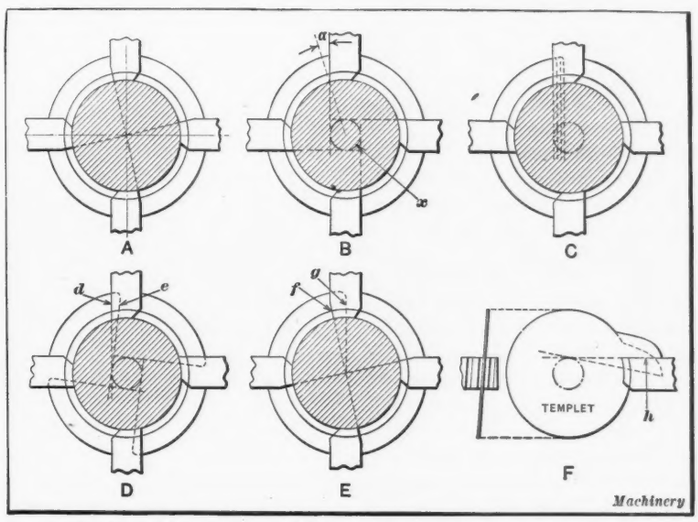


Fig. 35. Rake Angles or Relation between Front Face of Chaser and Axis of Work

Effect of Clearance or Relief of Chaser Throat on Action of Die

The relief or clearance at the throat of a chaser should be just enough to insure free cutting, and is subject to variation according to the diameter of the die or the screw that is cut by it and often by the conditions under which the die is used. It is essential to have the correct amount of relief back of the throat, because insufficient relief may prevent cutting action altogether or retard the action of the die, and prevents it from advancing at the proper rate. If a die has excessive relief, the chaser teeth are weakened and the die tends to move forward too rapidly when controlling its own lead, especially when cutting soft material like brass. The result is that threads are left rough and may be almost entirely cut away in extreme cases. If the rear or turret side of the thread is rough, this indicates that the die is leading or advancing too fast; and if the opposite or front side is rough, this shows that the die is not advancing fast enough. The leading of the die or the rate of its advance may be varied by changing the amount of relief or clearance in the throat of the die chaser. The greater the relief, the faster the die will lead, and *vice versa*. Relief, however, is not the only thing that may affect the leading qualities of a die. This point will be considered more fully later.

Grinding Throat of Die Chaser

The throat of a die chaser should be ground both with reference to its inclination relative to the axis of the die and also the amount of relief or clearance for the cutting edge. If the chasers to be ground have hobbed teeth or milled teeth which are circular in a lengthwise direction, it is common practice to use a wheel which is from 1/16 to ¼ inch larger in diameter than the nominal size of the die or the size of the screw the die is intended to cut. Ordinarily, a wheel about ⅛ inch larger than the die size is employed. The center of the wheel is offset relative to the center line of the chaser when grinding, in order to obtain clearance for the cutting edge of the throat. The exact method of grinding depends upon the type of machine used. In some cases, the chaser is held in a fixture which can be tilted to the throat angle and is graduated to indicate both the angular position and the amount that the chaser is offset relative to the wheel. The fixture shown in Fig. 29 is in the form of a block arranged to hold a chaser at the three angles recommended, by changing the position of the chaser and block.

The amount of clearance back of the cutting edge should be as small as possible without preventing a free cutting action. While it is common to use a wheel that is about ⅛ inch larger than the nominal size of the die, the use of a larger or smaller diameter wheel has less effect on the amount of clearance than the distance that the wheel is offset. For instance, if the wheel has a radius r (see diagram *A* Fig. 32) and this wheel is offset an amount x, a certain clearance will be obtained. Now if the size of this wheel were increased to some radius R, this would not affect the clearance to any great extent, assuming that the amount of offset x remained the same. On the other hand, if a wheel having a radius r is offset first a distance x and then some greater distance y, as shown by diagram *B*, this will increase the amount of clearance decidedly.

As a general rule, most of the grinding should be done on the throats of chasers, the faces being ground as little as possible. Repeated grinding on the throat extends the latter back farther from the leading side of the chaser (assuming that the same throat angle is maintained as it should be); if, as the result of repeated grinding, the die finally will not cut a full thread close enough to the shoulder, this can sometimes

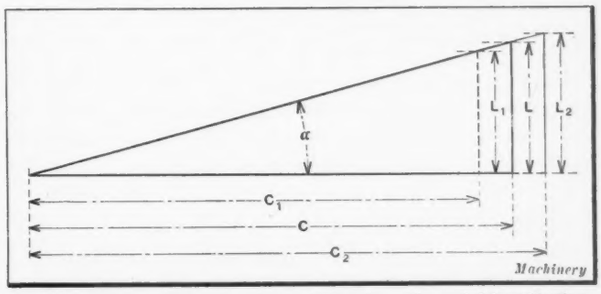


Fig. 36. Diagram showing how Lead of Thread may be varied by adjusting Die Chasers too much above or below Diameter for which Die is intended

be remedied by grinding away the front edges of the chasers, so that they will clear the shoulder.

The method of grinding the throat of a hobbed chaser with a "Geometric" chaser grinder is illustrated in Fig. 33. A large grinding wheel is used in this case and the chaser is swiveled about the wheel to give the clearance surface or throat a curved form. If the chaser for a one-inch die is to be ground, the scale on the pivot of the vise is set to the radius of the die or one-half inch minus the depth of one tooth or thread. The die is located by a stop on the vise and the jaws of the latter are adjusted to the right or left of the center (depending upon whether the chaser is for right- or left-hand threads) just enough to give the proper clearance. After releasing the swiveling base of the vise-slide by unscrewing the small handle shown, the chaser is ground by swinging it to and fro about the wheel, at the same time slowly feeding it in toward the wheel by turning the handwheel of the slide feed-screw of the vise. After grinding one chaser a stop ring is set to control the inward feeding movement so that the remaining chasers of the set are ground alike, or to correspond with the first one. When using the same machine to grind the throat of milled chasers having straight teeth, the die is traversed back and forth across the face of the grinding wheel; as the chaser is being traversed it is also fed forward by the handwheel of the feed-screw.

Fig. 34 illustrates a method of grinding the throat of a spring die. A cone-shaped wheel of suitable diameter is used, the axis of the wheel being offset slightly with reference to the axis of the die to give the throat or chamfered part a slight relief. Spring dies are not ordinarily ground in the throat, but are sharpened by grinding the radial cutting faces with an ordinary dish-shaped or saucer wheel, as explained later. If dies have been forced to cut when dull, they may be injured to such an extent that some grinding in the throat as well as along the cutting faces is necessary in order to obtain a sharp cutting edge. If the throat is ground away considerably, it may be necessary to grind back the ends of the lands or prongs, especially if there is a shoulder on the work which would strike these prongs before the thread has been cut the required length.

It is of especial importance to have as little clearance as possible on the chasers used for brass work because the throats of the chasers steady the die when starting to cut a thread. When it is desired to cut a thread close up to a shoulder in brass, the chaser teeth are sometimes relieved on the sides instead of chamfering the teeth. This relieving may be done by means of a brass lap, the working edge of which is formed to an angle of about 50 degrees for a 60-degree tooth, so that the lapping may be confined to one side of a tooth. This beveled or working edge of the lap is charged with a suitable abrasive and the side clearance is given to two or three of the leading teeth. When chasers are set tangent to the work as shown at *C*, in Fig. 28, the throat like the teeth has a natural clearance due to its tangential position.

Rake Angles or Relation between Chaser Cutting Face and Axis of Work

The relation between the front cutting faces of die chasers and the axis of the screw thread that they are used to cut varies for different materials. As a general rule, the front face of each chaser in a set lies in a plane intersecting the axis of the die or screw thread (as shown at *A*, Fig. 35) when the die is to be used for cutting threads on cast brass. For yellow brass, machine steel or tool steel, the chasers are usually given rake by locating the cutting faces in planes that are in advance of the center on the cutting side, as shown at *B*. There is considerable difference of opinion among manufacturers and users of dies as to the amount of rake that will give the best results. As a general rule the tenacious or tougher materials which have the quality of flexibility without brittleness, like wrought iron, steel, copper, and pure aluminum require positive rake. If there is not enough rake, more power is required for revolving the die or work and the chasers tend to tear the metal. Materials having a granular structure like cast brass and cast iron should ordinarily be cut with chasers having little or no rake. An excessive amount of rake would cause the chasers to ride and dig in alternately. Some grades of cast iron may be threaded satisfactorily with dies intended for steel. Most aluminum castings, because of the zinc in their composition, cut very much like brass and should preferably be threaded with chasers with little or no rake.

Many dies used for cutting threads in machine steel have the front faces located a distance ahead of the center equal to about one-fifth the radius of the die. In other words, the plane of the front face is tangent to a circle x, see *B*, Fig. 35, having a radius equal to one-fifth the radius of the die or a screw cut by the die. The angle a corresponding to the rake of the die chaser, is about 12 degrees when the front face is one-fifth the radius off center. This rake corresponds approximately to the angle of rake or slope that would be given to a lathe turning tool for use on machine steel, although the rake is, of course, subject to more or less variation. For threading copper and tobin bronze, dies having a rake of about 14 degrees have given satisfactory results. Die chasers are sometimes given negative rake when the die is to be used on very soft "greasy" brass, the face of the die being slightly back of the center instead of in advance.

Some of the die chasers for the Wells self-opening die are ground to a slight angle along the front face above the throat instead of leaving this face parallel to the axis of the die

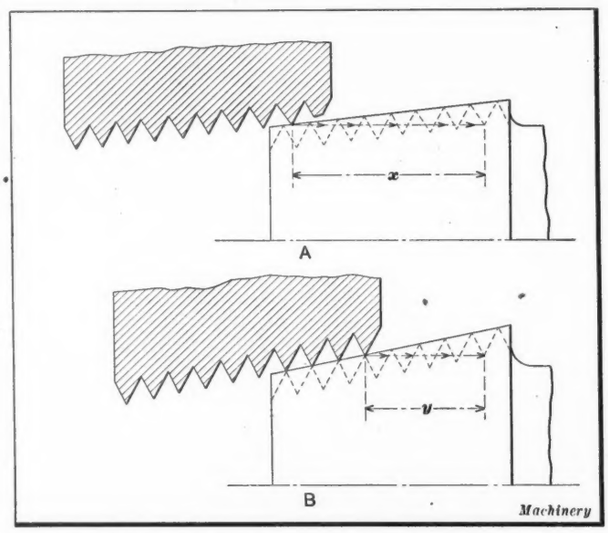


Fig. 37. Views illustrating how Longitudinal Movement of Solid Die for Taper Threading is reduced as Taper increases

or the screw which the die is to cut. It is claimed that a die equipped with such chasers tends to throw the chips ahead and avoid clogging. This method of grinding the die chasers is the same in principle as that employed on the "gun taps" made by the Greenfield Tap & Die Corporation.

Maintaining Rake Angle of Chaser when Grinding

The front faces of chasers should always be ground so that they are in the same position relative to the axis of the die assuming that the die has been cutting properly and a change is not desired. Chasers located with the front faces in advance of the centers (as illustrated at *C*) are sometimes ground back so that the faces are always parallel to the side of the chaser (as indicated by the dotted lines) which reduces the angle of rake and impairs the cutting action of the die. In order to maintain this angle, it is necessary to incline the faces of the chasers as they are ground back so that they will remain tangent to a circle at the center representing the amount of offset as indicated by diagram *D*. When a chaser has been ground back considerably it appears to have more rake, which may account for the difference of opinion in regard to rake angles. A chaser which is radial may also appear to have "positive" rake after repeated grinding, even though the cutting face is still in a radial position. For instance, when the chaser face is at f (see diagram *E*) the cutting action will be practically the same as when the chaser is

ground back to some point *g*, since the cutting faces are radial in each case. If the position of the cutting face, however, relative to the axis of the work were not considered, one might naturally suppose that a chaser ground as at *f* would have negative rake, whereas with the cutting face at *g* there would be positive rake.

A simple form of templet and the method of using it to test the front cutting face of a chaser is illustrated at *F*. This templet is made of thin sheet steel and it has the same radius as the die or the outside radius of the screw the die is to cut. The gaging edge *h* is given the same location relative to the axis of the templet that the cutting faces of the chasers are to have relative to the axis of the die. The gage is used by simply placing it between two chaser teeth and turning it around until the testing edge *h* is in contact with the chaser face that should coincide with it. If a die is to work satisfactorily, each cutting face must be in the same position relative to the center or axis of the die. Dies are frequently used which have one cutting edge in a radial position and the others somewhat in advance of the center or back of it. A die ground in this way will not do good work especially when cutting threads in steel. In order to maintain a uniform rake angle all chasers should be ground so that the faces of chasers that are diametrically opposite are parallel, assuming

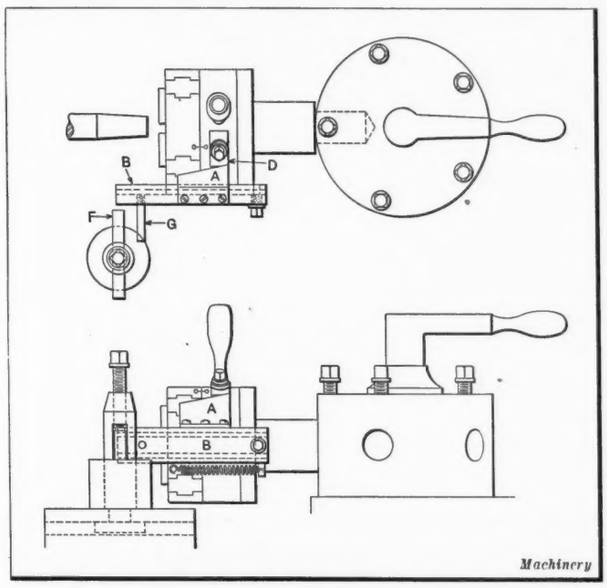


Fig. 38. Geometric Self-opening Taper-threading Die-head of Outside Trip Type

that the die has an even number of chasers. The rake of a chaser of the tangential type (see diagram *C*, Fig. 28) may, of course, be varied according to the requirements by simply grinding the end of the chaser to the angle desired.

Causes of Lead Errors in Die-cut Screw Threads

The accuracy of a die-cut thread depends primarily upon the cutting edges of the die or form of the chaser teeth and the rate at which the die advances for each revolution. Most dies are self-propelling or self-leading and move along as the screw is cut, except when the die is held stationary and the work is revolved, in which case the action is reversed but is similar so far as the practical result is concerned. As is well known, this motion of the die relative to the screw or *vice versa*, is due to the fact that the cutting teeth lie in a helical path; consequently, as one tooth cuts a thread groove the next successive tooth follows in the same groove and even though it may cut the groove deeper, it serves in part, to steady the die like the section of a nut and force it to advance at a rate equal approximately at least to the lead of the helical path in which the die teeth lie. If a die has too long a throat or one extending back over quite a number of teeth it may act somewhat like a reamer when starting and merely cut away the end of the screw blank instead of forming a thread. This reaming or turning action is due to the fact that each tooth along the throat cuts such a shallow groove that the following teeth do not have sufficient bearing surface in the groove to guide the die and force it to advance along a helical path; the result is that the die either does not advance along the screw thread or moves so slowly that the teeth at the throat merely cut off the end of the screw blank.

It is evident that under certain conditions a self-leading die may not advance at the proper rate and cut a thread of correct or uniform lead. There are several reasons why lead errors occur in die-cut screw threads. To begin with, the die or die-chaser teeth may have been cut with a hob or milling cutter of incorrect lead. The pitch of the die teeth may also have been changed as a result of shrinkage in hardening. Even though the die teeth are accurate as to pitch, the lead of the thead may not be correct, which indicates that the die does not advance a distance per revolution of the work or die, as the case may be, corresponding to the lead of its own teeth. The result is that the full sized thread that would otherwise be formed is cut away partially, thus producing a thread that is incorrect as to shape and lead.

The advance movement of a die may be affected by the amount of relief or rake at the throat of the die. If the die is ground so that it has plenty of clearance at the throat, the edges tend to feed in faster, especially when the front face has considerable rake in addition to the relief; consequently, the die tends to move forward farther for each revolution of the work than the lead of its teeth or the screw being cut. On the contrary, if there is insufficient relief the forward movement is retarded. The action may also be affected by dull cutting edges at the throat or by the length of the throat or chamfer.

The advance of a self-leading die of the adjustable class is sometimes affected by adjusting it too much in one direction or the other from the standard size for which the chasers were hobbed. There are certain limits above or below the standard or nominal size within which it is practicable to adjust threading dies without affecting the lead to any appreciable extent. If the diameter for which the die is adjusted is too large, the lead of the thread will be increased; whereas, if the die is adjusted too much under size the lead will be reduced. The changes in lead are due to the angle of the helical threads being the same for the different diameters. This point is illustrated by the diagram Fig. 36, in which L represents the lead of the threading die; C, a circumference corresponding to the standard diameter for which the die is intended; C_1 a smaller circumference; and C_2 a larger circumference. Angle α represents the standard helix angle or the angle of a path which coincides with the die teeth. If a thread is cut to this angle α on a circumference C_1 that is considerably less than circumference C corresponding to the standard size of the die, the lead will be reduced from L to L_1 and if the same thread is cut on a larger circumference C_2, the lead will be increased as indicated by dimension L_2. This is just what happens when the die is adjusted for a larger or smaller diameter than the standard. (It is assumed that the adjustment is not so great as to cause the "heels" of the chasers to drag excessively and prevent cutting action because of the lack of clearance.) The teeth of the die naturally tend to cut a thread having the same helix angle as that represented by the helical path in which the chaser teeth lie. If the diameter of the screw blank is larger than the standard, the die advances farther than it should per revolution; the result is that the lead is increased and, consequently, in the case of a U. S. standard thread, the width of the flat is reduced at the top of the thread and increased at the bottom, for successive chaser teeth cut away the left-hand side of the thread groove as the die moves to the left. The thread form undergoes a similar change if the die is applied to a diameter smaller than the standard, but in such a case the rate of advance per revolution is less than it should be and the successive chaser teeth cut away the thread on the right-hand side of the thread groove as the die moves to the left. The fact that the lead is long in the first case mentioned causes each successive chaser tooth back of the die throat to cut along the left-hand side of the thread groove as mentioned. When the lead is less than it should be, the chaser teeth remove metal from the opposite side of the thread

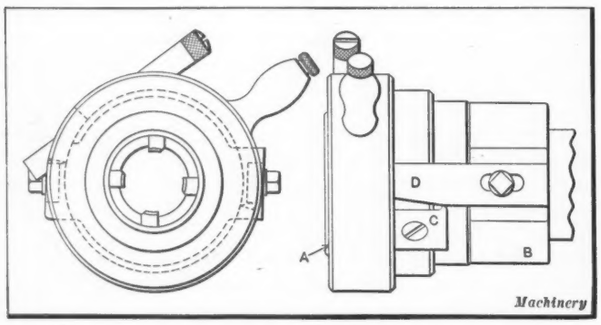


Fig. 39. Hartness Die-head for cutting Tapered Screw Threads

section. If the chasers in either case were long enough or had enough teeth following the throat, the successive action of these teeth on the side of the thread would remove the thread entirely.

Lead variations in die-cut screw threads are sometimes due to a drag on the die or excessive resistance to its motion, such as may result if the die is attached to a heavy turret slide which does not follow up the die properly. The common method of avoiding drag such as would occur if the die were forced to pull a heavy turret slide along with it is by using a die-holder of the type previously referred to, which has a certain amount of lost motion or float so that the turret slide may lag behind and the die will continue to advance independently of it, provided the lost motion in the holder is not completely taken up. When the die must pull a slide along with it the gibs of the slide should be loosened somewhat to reduce the friction as much as possible. An excessive backward pull on the die naturally causes the teeth to generate a helical path, the lead of which is somewhat less than the lead of the die, because the cutting edges on the rear sides of the teeth are forced against the side of the thread groove and gradually reduce the rate of advance by cutting on that side.

When a die or other type of thread-cutting tool produces a screw thread which seems to be inaccurate, the discovery is often made that the defect is in the thread gage rather than in the tool itself. The manufacturers of thread-cutting equipment frequently find that accurate screws and well constructed tools are condemned because of inaccurate thread gages.

Positive Control of Die-feeding Movement

While most dies are "self-leading," it is sometimes advisable to control positively the longitudinal motion of the die relative to the work. This control may be utilized merely to start the die, or the arrangement may be such that the longitudinal motion of the die is controlled positively throughout the entire screw-cutting operation. This positive action may be derived from a lead-screw or from a cam, depending upon the type of machine. When a lead-screw is applied to a threading machine of the bolt-cutter type, it is geared to the die-spindle so that the work-slide is advanced a distance equal to the lead of the thread for each revolution of the work, the same as when cutting a thread in a lathe with a single-point tool. When cutting threads such as the U. S. standard, V-threads, or the Whitworth thread, a good die will follow the lead accurately enough for all ordinary commercial requirements. When cutting square threads, however, or special forms such as the rachet thread, a lead-screw should be used to control the longitudinal motion of the work relative to the die, especially if the pitch is coarse. For screw-cutting operations of this kind, if the die follows its own lead the accumulated error is often considerable; that is, the lead error between two threads might be small, but the total error in the length of the screw, or a section of it, might be considerable. By using a lead-screw, the die is prevented from increasing or decreasing the lead, but to secure satisfactory results it is, of course, essential that the pitch of the die teeth correspond to the leading movement obtained from the lead-screw. It is important to eliminate lost motion in the drive to the lead-screw as far as possible, and the screw should be large and strong enough to resist the torsional strains without excessive distortion. If more than one cut is required, as when cutting a screw of coarse pitch, an indicator or thread-chasing dial of the type used on engine lathes for catching the thread is convenient on a die threading machine having a lead-screw.

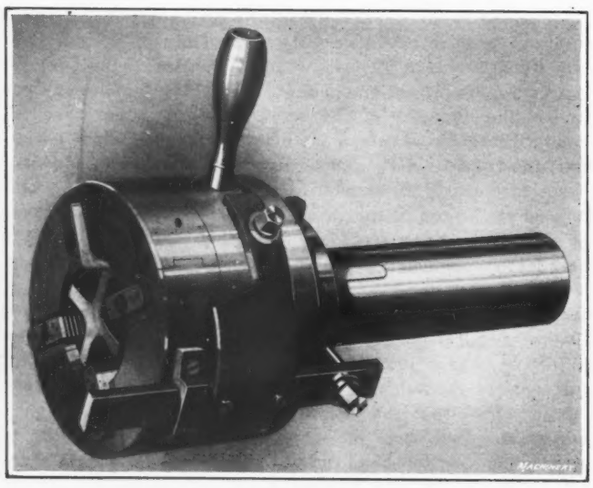


Fig. 40. Geometric Taper-threading Die of Inside Trip Type

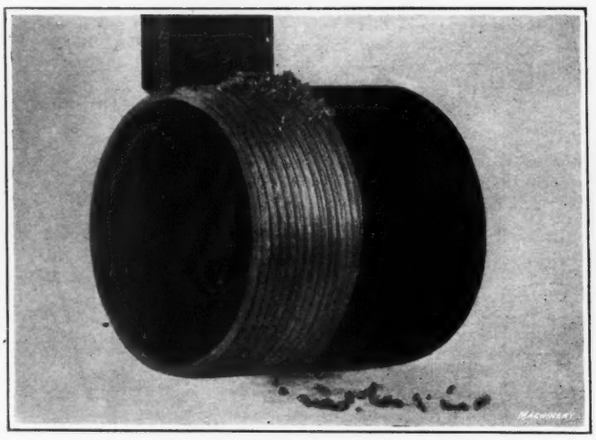


Fig. 41. Rough, Poorly formed Pipe Thread cut with Die having Insufficient Rake

The general method of cutting threads on the automatic screw machine is to use a cam that starts a die onto the work and then allows the turret slide to lag behind somewhat so that the die can lead itself on. As previously explained, lost motion in the die-holder allows the die to follow its own lead or move independently of the turret slide.

Maximum Pitch of Thread Cut with Dies

The maximum pitch of thread that can be cut satisfactorily with a threading die may, of course, be subject to considerable variation. It may depend upon several factors, such as the design of the die in regard to rigidity, the accuracy required in the screw thread, the degree of finish or smoothness, the relation between the pitch of the thread and the diameter of the screw, and the condition of the chasers, especially as to sharpness. As a general rule, when the pitch is coarser than four or five threads per inch, the difficulty of cutting threads with dies increases rapidly although some dies are used successfully on screw threads having two or three threads per inch or less in extreme cases. Some die manufacturers would regard these pitches as too coarse for dies, whereas others have proved in actual practice that dies may be constructed which are capable of handling such heavy thread-cutting operations, if other conditions are favorable to the use of dies. Of course, dies of special design could be constructed for practically any pitch if the size of the die, its cost and the power for driving it were regarded as secondary, and the

screw blank were strong enough to resist the cutting strains.

When considering the use of a die on a thread of coarse pitch, it is important to bear in mind the relation between the pitch of the thread and its diameter. If the screw diameter is relatively small in proportion to the pitch, there may be considerable distortion of the screw due to the torsional strains set up when cutting the thread with a die. For this reason, dies for coarse pitches work better when cutting threads on screws which are large enough in diameter to resist the torsional or twisting strains. As a general rule if the number of threads per inch is only one or two less than the standard number for a given diameter, the screw blank will be strong enough to permit cutting the thread with a die without excessive distortion. When a coarse thread is cut by the milling process, the cutting is done, of course, much more gradually and there is not the same difficulty due to a twisting action that is encountered when using a die of coarse pitch on comparatively small diameters.

Cutting Taper Threads with Dies

Taper threads may be cut by using dies with chasers which taper to correspond to the taper on the work and are arranged to move outward radially as the die traverses toward the large end of the taper; by using dies of the solid or non-opening class which have the same taper as that required on the work, assuming that the length of the threaded part does

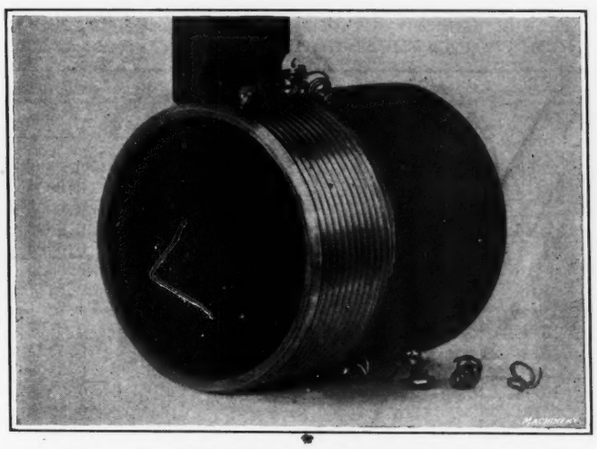


Fig. 42. Result obtained when Die is given Proper Amount of Rake

not exceed the length of the cutting edges on the die or the width of the chasers; by using dies intended for parallel threads and arranged to open radially for producing a taper thread. The first type of die referred to, which has tapering chasers that move outward in accordance with the taper, is preferable for the most accurate work. The solid or non-opening die which simply tapers to correspond to the taper screw thread to be cut, is not only limited to comparatively short screw threads but does not produce a very satisfactory thread because ridges are left wherever each cutting edge stops cutting. The use of a solid tapering die also subjects the work to considerable torsional strain (which might be objectionable) because there are more cutting edges at work at the same time and the power required to turn the die increases as the length and taper increases. The greater the length the more cutting edges will be at work simultaneously, and the more abrupt the taper the less the number of revolutions of the die for completing the thread. The effect of the taper on the number of revolutions for completing the thread is illustrated at *A* and *B*, Fig. 37. In one case the die moves inward a distance x before the teeth cut to full depth, but when the taper is more abrupt, as shown at *B*, the die only needs to move longitudinally a distance y, in order to cut the full depth of thread.

The third method mentioned, by which a die for straight thread cutting is used for tapering work, may be applied to cutting threads having a slight taper, but is not recommended for the usual classes of taper work, which include such parts as wash-out plugs for steam boilers, the ends of faucets or cocks of various kinds, buffing lathe spindles, etc. A tapering

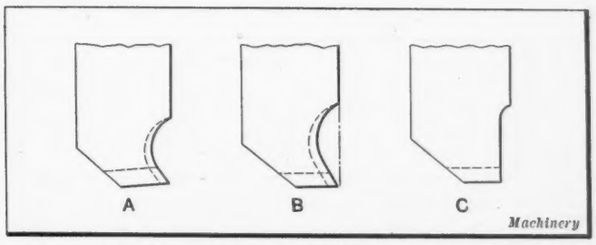


Fig. 43. Different Methods of grinding Chasers of Pipe-threading Dies

die of the non-opening class does not require a throat or chamfered teeth on the leading side unless the taper is slight, because several cutting edges begin work at the same time, as indicated at *B*, so that there is no need for a throat, since the object of the chamfered edges in a straight die is to start the cut gradually between several teeth, instead of having one leading tooth cut the thread groove to the full depth.

Self-opening Taper Threading Dies

A self-opening die-head for taper threading differs from one used for parallel or straight threading in that the chasers move outward at a rate depending upon the angle of taper, until the thread is cut, and then move outward suddenly to clear the work, instead of remaining in one position until the completion of the thread-cutting operation. The radial movement of taper threading die chasers is ordinarily controlled by means of a tapering former plate, which allows the cam or scroll ring of the die-head to turn slowly as the die advances, the rate of this turning movement depending upon the angle of the former plate relative to the axis of the die. The former plate serves about the same purpose as the adjustable slide or bar of a taper attachment for the engine lathe. Taper threading dies of the self-opening class may be either of the inside or outside trip type.

A "Geometric" die of the outside trip type is shown applied to a turret lathe in Fig. 38. A tapering plate *A* is attached to a taper bar *B*, which is free to slide over a guide of T-shaped section. This guide is attached to the front part of the die-head, but not to the cam ring, which is free to turn and carries a lug *D* that is in contact with the former plate. *A* stop *F* is clamped in the toolpost (or is bolted to the side of the cross-slide) in position to engage pin *G* projecting from taper bar *B* of the die-head. This stop is so located that it holds bar *B* stationary as the chasers begin cutting the thread. As the die advances, lug *D* slides along the tapering surface of plate *A*, which causes the cam ring to turn slowly and the chasers to move out gradually for producing a thread, the taper of which depends upon the inclination of the former plate. When lug *D* reaches the end of plate *A* it drops off and the chasers fly outward radially, thus releasing the die, which is then withdrawn. Die-heads of this kind are made specially for a given class of work, and in many cases must be arranged with reference to the screw machine or turret lathe on which they are to be used.

The Hartness die-head for cutting tapering threads is illustrated in Fig. 39. The front section *A* of the die-head, and the cam ring for controlling the action of the chasers, slides on the rear or shank end, which is held in the turret. The forward movement of the shank of the die is arrested by one of the regular turret slide stops after the chasers have begun to

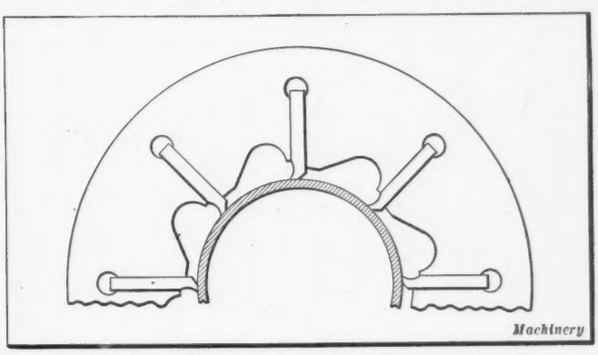


Fig. 44. Approved Form of Chip Space for Pipe-threading Die

TABLE 1. SURFACE SPEEDS FOR CUTTING SCREW THREADS IN STEEL WITH DIES

Material to be Threaded	Steel for Chasers	Surface Speeds in Feet per Minute for Different Pitches			
		3½ to 5½ Threads per Inch	6 to 7½ Threads per Inch	8 to 11 Threads per Inch	12 to 32 Threads per Inch
Hard Steel	Carbon	8	10	12	15
	High Speed	10	12	15	20
Mild Steel	Carbon	12	15	20	25
	High Speed	15	20	25	30

Machinery

cut the thread. The front section of the die then continues to advance until lug *C* reaches the end of the tapering former plate *D;* as soon as lug *C* and plate *D* are disengaged, the cam ring quickly turns part of a revolution and the chasers are opened. Another lug and former plate are located on the opposite side of the die-head, as there is a floating connection between the two sections of the die-head.

A "Geometric" taper threading die-head of the internal trip type is illustrated in Fig. 40. When this die-head is moved up to the working position, the end of the work comes into contact with the cross-shaped gage or stop located inside the die-head. This gage is connected with the taper bar that carries the former plate, and as the chasers begin cutting the thread, the gage and taper bar are held stationary. The length of thread that is cut depends upon the position of the gage or stop, which is set previously. When the chasers have advanced the required distance, the cam lug slides off the tapering plate, thus allowing the cam controlling the chasers to make a partial turn and open them quickly.

When dies of the former-plate type are in operation, the chasers follow the taper of the work automatically and no more power is required for cutting a taper thread than for cutting a straight thread of corresponding diameter and pitch. These dies make it possible to do the work rapidly and produce accurate smoothly finished screw threads. The working edge of the former plate on dies of this class should so control the turning movement of the cam ring that the resultant of the longitudinal and radial movements of the chasers conforms to a straight line, so that the tapering screw will not be convex or concave. The edge of the former plate would be a true helix if the chaser cam had a uniform rise, but since it is more convenient to make these cams plain circular arcs located eccentrically to the axis of the die, the edge of the former plate may not be made truly helical, especially if the taper of the thread to be cut is rather abrupt; for cutting threads having slight taper, it would not be necessary to modify the former plate, as the error would be quite small; in fact, a plain inclined edge not of helical form would produce work accurate enough for ordinary requirements.

TABLE 2. REVOLUTIONS PER MINUTE FOR GIVEN SURFACE SPEED AND DIAMETER

Diameter of Screw Thread	Surface Speed in Feet per Minute						
	8	10	12	15	20	25	30
	Revolutions per Minute for Different Surface Speeds						
⅛	244	305	366	458	611	764	917
¼	122	153	183	229	306	382	458
⅜	81	102	122	153	204	255	306
½	61	76	92	115	153	191	229
⅝	49	61	74	92	122	153	184
¾	41	51	61	76	102	127	153
⅞	35	44	53	66	88	109	131
1	31	38	46	57	76	95	115
1¼	24	31	37	46	61	76	92
1½	20	25	31	38	51	64	76
1¾	17	22	26	33	44	55	65
2	15	19	23	29	38	48	57
2¼	14	17	20	25	34	42	51
2½	12	15	18	23	31	38	46
2¾	11	14	17	21	28	35	42
3	10	13	15	19	25	32	38

Machinery

When the work is stationary and the die-head revolves it may be arranged as follows: The bar to which the former plate is attached carries a roller at its outer end, which runs around a ring the surface of which is in a plane at right angles to the axis of the machine spindle. This ring may be attached wherever convenient, and it serves merely to hold the former plate stationary while the die-head advances.

Cutting Smooth Threads on Pipe

Many dies used for cutting threads on pipe do not give satisfactory results, ragged or torn threads often being produced. After the introduction of steel for pipes, defective threads were even more numerous than before, although it has been demonstrated that steel pipe can be threaded as rapidly and efficiently as wrought iron when the correct form of die is used. Experiments of the National Tube Co., Pittsburg, Pa., for determining the cause of defective pipe threads showed that the angle of rake is of particular importance. Other important factors are as follows: lack of adequate chip space; improper grinding of the throat; excessive or insufficient clearance; and incorrect number of chasers. Steel pipe is naturally soft and tough, and for that reason it was more difficult to thread with some of the dies used for wrought iron which had radial cutting faces or chasers without positive rake. Fig. 41 shows the kind of pipe thread that is cut when the die is without rake and simply pushes the metal off, instead of operating with a clean cutting action. Fig. 42 illustrates the results obtained when the chaser is properly made and ground. This die has positive rake, which is preferable for wrought iron as well as steel. The form of chaser illustrated at *A*, Fig. 43, is recommended for cutting ordinary steel pipe. The form of cutting edge illustrated at *B* is recommended for use on open-hearth steel pipe, which requires a rather long and gradual "lip" or curvature back of the cutting edge, owing to the toughness of the material. The form of chaser illustrated at *C* is considered unsuitable for threading either steel pipe or wrought iron. The angles of rake recommended vary from 15 to 25 degrees, depending upon the conditions. For threading open-hearth steel pipe, the rake angle should be 25 degrees.

TABLE 3. THREAD CUTTING SPEEDS FOR DIES BASED ON REMOVING AN EQUAL AMOUNT OF METAL PER MINUTE

Diameter of Screw Thread	Number of Threads per Inch	Revolutions per Minute	Surface Speed, Outside Diameter	Cubic Inches Removed per Minute
1/4	20	1062.0	69.5	0.5896
5/16	18	691.5	56.5	0.6004
3/8	16	453.0	44.5	0.6025
7/16	14	297.5	34.0	0.6009
1/2	13	224.5	29.0	0.6084
9/16	12	169.5	25.0	0.6085
5/8	11	128.7	21.0	0.6147
11/16	11	117.0	21.0	0.6201
3/4	10	88.5	17.0	0.6177
13/16	10	81.7	17.0	0.6225
7/8	9	61.7	14.0	0.6170
15/16	9	57.6	14.0	0.6276
1	8	40.6	10.6	0.5948

Machinery

It is important to have the proper amount of space in front of each chaser to allow for the accumulation of chips. If there is not enough space, the chips frequently pack tightly in front of each chaser and mar or tear the thread. An approved form of chip space for a pipe die is illustrated in Fig. 44. The curvature of this space is such as to provide an easy path for the chips to follow; at the same time, the back of the chaser is rigidly supported. The chip space is of especial importance on dies intended for cutting open-hearth steel pipe, because the chips from this material are usually long and tough.

The throat or chamfer of pipe dies should extend over about three threads or teeth. As the heaviest cutting is done in the throat of the die, this section should have a little more clearance than the rest of the chaser teeth, which applies to threading dies in general. If a tooth in a die is broken away, it is preferable to remove the remaining part entirely by grinding with a thin wheel, because the broken part tends to tear or roughen the thread. To obtain the best results with pipe dies,

the number of chasers should be varied according to the size of the die, four chasers being used for diameters up to 1¼ inch; six chasers for diameters from 1½ to 4 inches; eight chasers for diameters from 4½ to 8 inches; twelve chasers for diameters from 9 to 12 inches; fourteen chasers for diameters from 13 to 16 inches; and sixteen chasers for diameters from 17 to 20 inches.

Cutting Square Threads with Dies

The cutting of square threads with dies is usually regarded by die manufacturers as a difficult proposition, and unless the die is made very carefully unsatisfactory results are obtained. While square threads have largely been replaced either by the Acme or another form, some manufacturers prefer the square thread, and occasionally they are cut by means of dies. The chasers for square threading dies that are to be self-leading should have teeth that are slightly relieved on the sides by lapping. Unless there is a little side relief, the chaser teeth bind and are frequently broken. If the die is to be self-leading, however, the side relief or clearance must be very slight, as otherwise the die will not be properly supported and will cut a very inaccurate thread as to lead. A die of this kind should preferably be controlled by a lead-screw and the chaser teeth should be given enough side clearance to prevent binding. As the Acme thread is superior to the square thread and may readily be cut with dies or taps, the use of dies for square threads is not common.

Steel for Threading Die Chasers

There is some difference of opinion regarding the relative merits of carbon steel and high-speed steel for the chasers of threading dies. The results obtained with different steels may, of course, depend considerably on the exact composition of the steels in question and the heat-treatment to which they are subjected. In general, carbon steel chasers are preferable for cutting smooth, accurate screw threads, owing to the fact that they retain a fine cutting edge better than chasers made of high-speed steel. A fine sharp cutting edge on a high-speed steel chaser is not affected by hardening and tends to crumble slightly when the chaser is first used. The result is that screw threads cut with high-speed steel chasers are not so smooth, although the cutting speed can be considerably higher. As a general rule, carbon steel is recommended when finish is of especial importance, whereas high-speed steel is preferable when maximum production is the principal object and a nicely finished thread is of secondary importance. Incidentally, many manufacturers or users of dies order the more costly high-speed steel when carbon steel or "semi-high-speed steel" would be preferable. The semi-high-speed steel, which has been used for many die chasers, contains much less tungsten than the steel ordinarily used for turning tools.

The National Acme Co. recommends the use of carbon steel chasers for cold-rolled screw stock, Bessemer and open-hearth steel, 3 per cent to 5 per cent nickel steel, malleable iron, brass, bronze and similar alloys. High-speed steel chasers, or those made of semi-high-speed steel, are recommended for cutting threads in chrome-vanadium steel, tough alloy steels, cast iron, drop-forgings and all heat-treated steels.

Amount of Carbon in Steel for Screw Stock

The kind of stock that is used often greatly affects the quality of thread that may be cut with a die, tap or other type of thread-cutting tool; in fact, the tool is often considered at fault when the stock is the real cause of the trouble. The so-called "screw stock" may have from 0.08 to 0.20 per cent carbon, with possibly 0.06 to 0.12 per cent sulphur; 0.30 to 0.80 per cent manganese; and phosphorus up to about 0.12 per cent. Ordinarily, a steel containing from 0.18 to 0.25 per cent carbon is very satisfactory for thread cutting, the carbon content preferably being about 0.20 per cent, or a little more. If there is too little carbon in the steel, the metal is stringy or tends to tear, and it is more difficult to cut a smooth thread.

Cutting Speeds for Threading Dies

There are few, if any, subjects connected with machine shop practice which are more difficult to deal with in a definite, specific manner than the general subject of cutting speeds, because there are so many different factors that may have a decided effect on the speed for any one operation. If cutting speed data based on past records or experience are not available, it is preferable to begin with a general idea as to what speeds are practicable than to be entirely in the dark. For this reason, general information on cutting speeds for threading dies will be given, and while the speeds listed may be subject to considerable variation, they will doubtless prove of some value as a starting point until tests can be made that will give more nearly correct cutting speeds.

When experimenting in order to determine what speed is the most economical, the speed should be increased gradually from a safe or conservative speed, until it is as high as possible without wearing or dulling the die chasers excessively. When a die is dulled it is not so easily resharpened as many other metal-cutting tools, and for that reason it is better to sacrifice the cutting speed somewhat in order to keep the die in good cutting condition for a longer period. As one prominent die and machine tool manufacturer expressed it, "Better half speed than a trifle too fast."

Just what the cutting speed in feet per minute should be depends not only upon the kinds of material being cut, but also upon the pitch of the thread and the kind of cooling compound or oil used on the die. The National Acme Co. gives the following general data on cutting speeds, based upon a vast amount of experience in screw cutting. Under normal conditions, a die equipped with carbon steel chasers should be operated at about 30 feet per minute (surface speed at the pitch diameter) when cutting threads in cold-rolled screw stock, Bessemer open-hearth stock, 3 to 5 per cent nickel steel, malleable iron, brass, bronze and similar alloys. A cutting speed of 20 feet per minute is advocated when using high-speed steel chasers or those of semi-high-speed steel for cutting threads in chrome-vanadium, tough alloy steels, cast iron, drop-forgings and all heat-treated steels. The speeds given, both for carbon and high-speed steel chasers, may be increased about 20 per cent when cutting threads of fine pitch.

The surface speeds given in Table 1 are recommended by the Jones & Lamson Machine Co. for cutting threads of different pitch in both hard and mild steel and when using either carbon or high-speed steel chasers. The figures in the body of the table represent surface speeds in feet per minute and not revolutions per minute. The speeds are increased considerably for the finer pitches, the speed recommended for from 3½ to 5½ threads per inch being increased approximately 100 per cent when cutting threads varying from 12 to 32 per inch. The revolutions per minute corresponding to these various surface speeds are given in Table 2.

Cutting speeds have been determined on the theory that the amount of metal removed by the die per minute should be the same for cutting screws of all pitches. For instance, if a die is found to operate satisfactorily when cutting a thread in a certain material, whatever fractional part of a cubic inch of metal is removed per minute is determined, and then cutting speeds for the same material and for coarser or finer pitches are based on removing an equal amount of metal per minute. While this method seems to be logical, it involves a wide range of speeds if extended to include very coarse and very fine pitches. Table 3, which applies to U. S. standard threads, was calculated on the basis of removing approximately 0.6 cubic inch of metal for threads of all pitches. As the table shows, the surface speeds vary from 10.6 to 69.5 for U. S. standard threads ranging from 1 to ¼ inch in diameter, and the speeds in revolutions per minute for the same range of diameters vary from 40.6 to 1062. This table is based on actual practice in cutting threads on screw stock with self-opening dies at the plant of the Greenfield Tap & Die Corporation.

* * *

This summer 13,000 tons of coal, or 350 carloads, were floated down the Ohio River to Cincinnati by means of an artificial flood. Dams on the various tributary rivers were opened until an artificial crest of from three to six feet was formed, which was sufficient to float the fleet of barges.

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

CUTTING SCREW THREADS

Drilling holes and cutting screw threads are the most common machining operations. They are performed in the most primitive communities by blacksmiths whose knowledge of general machining methods is very limited indeed. Notwithstanding the commonness of threading operations, there is probably no other machining operation on which there is such a diversity of opinion; nor is there any for which so many kinds of tools, dies and machines are used.

The treatise on thread-forming processes begun in this number analyzes the operations of cutting screw threads with dies, milling cutters, taps and single-point tools; it describes the tools, and takes up phases of the general problem of thread making. The analysis of a fundamental process of machining will, we believe, be of great practical value to all classes of readers. Too little has been published in the past on fundamentals, and too much, perhaps, on collective work which should have been analyzed and separated into its basic operations. Given a knowledge of basic principles, the intelligent mechanic can adapt them to the production of any machine, tool or part, the same as a bricklayer, given bricks and mortar, can build walls of any structure that the architect designs.

One important service rendered by the publication of this treatise is the placing before the reader concisely of the various means and methods for making screw threads and the classes of work for which they are best suited. Every machinist is familiar, no doubt, with the various methods of making screw threads, but few have a clear conception of the classes of work for which each is best adapted. For example, during the past few years thread milling has come to the front as a method of producing accurate threads, true to pitch and thread shape. It is important for the production engineer to know when and where thread milling should be used in preference to the older and better known methods.

* * *

INTERCHANGEABILITY IN MANUFACTURE

The production of modified Lee-Enfield rifles required for the army is being delayed because of certain difficulties encountered by the army officers in charge, due to lack of interchangeability of work produced by the three concerns now manufacturing these rifles in the United States. Interchangeability is a highly desirable feature of any manufactured product, but it is not absolutely vital to the success of a rifle that its parts shall be strictly interchangeable with the same parts of all other rifles of the same model used by our army. Strict interchangeability is most highly desirable for the bolt and component parts. The fitting of new barrels to rifles in the field is practically never done, nor is the reassembly of other important component parts attempted.

Interchangeability is a feature of modern manufactured products that has been highly advertised as something of great value to the users. One manufacturer of rifles has for many years published a statement in his catalogue in regard to interchangeability that is absolutely misleading. The statement is to the effect that the rifles manufactured by the company are made interchangeable at great expense in order that the users shall be able at any time to replace broken parts without fitting or trouble. As a matter of fact, interchangeable manufacture was developed because parts can be made cheaper under a strictly interchangeable system than where each part is made by methods that do not insure accuracy of dimensions and shape. The cost of fitting and assembling then becomes excessive. A rifle made with strictly interchangeable parts can be assembled rapidly, and the assembly cost is low. When that is said, practically everything is said in favor of the interchangeable system from the manufacturer's viewpoint. The advantage of the user being able to replace broken or worn parts without fitting is incidental, and would be generally neglected were it not for the saving in manufacture.

In the case of the three great concerns making Lee-Enfield rifles, each has developed the interchangeable system for itself; but the tolerances are not in agreement, so there is not strict interchangeability of the parts made by the three concerns. It hardly seems desirable from any practical standpoint to hold up production of the rifles so badly needed in order that an ideal interchangeable system of manufacture may be perfected.

* * *

THE NEW MECHANICAL ENCYCLOPEDIA

Throughout this country there are thousands of men who are experts in their respective lines of endeavor. They have become experts by accumulating knowledge gained through personal experience, by contact with other well-informed men, and through their studies; their minds are storehouses of mechanical knowledge. If this knowledge could be transferred to the pages of books, the result would be an encyclopedia of mechanical information that would prove of incalculable value to the mechanical world at large. Such a record of experience would be invaluable to those who otherwise would have to gain this experience for themselves.

The mechanical and engineering fields have produced many excellent handbooks that present in condensed form valuable data based on what might be called the composite experience of hundreds of men, and no mechanic's library is considered complete without one or more of these; but no comprehensive work has been available relating to the machine-building trades that completely records the knowledge acquired by experience in this field in such a way that others may benefit by it. There are hundreds of books on various mechanical subjects; there are dozens of handbooks; but there has been no encyclopedia devoted to the thousands of questions and problems met with in machine design, construction and operation.

After a long time of preparatory work, MACHINERY has filled this gap in mechanical literature. The best mechanical ability engaged in actual practice in scores of the best known shops and designing offices in the country has been called upon to assist in this work, and comprehensive articles completely treating the various phases of the methods used in the machine building trade in design and construction, patternmaking, foundry work, machine shop practice, power plant requirements, electrical installations, etc., have been collected. In undertaking the publication of this great work, MACHINERY believes it has performed a distinct service to the mechanical trades, and hence deems it proper to announce the completion of the work in this manner.

ORGANIZATION

The Secretaries of the Army and Navy are civilians, in keeping with a government policy that has been found consistent and wise. But, unfortunately, the policy of employing civilians in charge of the production of army and navy munitions and material has not been followed. Is an army officer generally fitted by training to be the practical head of an armory? Experience has shown that he is not. He may know everything about an army rifle and its use, but that is quite different from knowing how to organize a manufacturing plant and conduct manufacturing operations efficiently and economically. His training has seldom included practical manufacturing experience.

We hope that one outcome of the present struggle will be the displacement of army and navy officers generally in charge of the production of our war material, in favor of civilians who are not politicians, but who by reason of their practical experience have shown themselves competent to organize and conduct great manufacturing operations as efficiently as some of the men who have volunteered for such work at the sacrifice of their personal interests.

Frank A. Scott, chairman of the War Industries Board, in replying to an attack by a well-known politican on a rifle contract awarded by the War Department, said, "The most valuable asset of the companies (to whom the contract was awarded) is their organization; and without that the machinery would be of no use." The American concerns now engaged in manufacturing rifles, other than those that were equipped for such work when the war began, required from twelve to twenty-four months to organize their plants before they turned out a single rifle; and the process of organization would be far more difficult now, because the mechanical executives and the equipment, especially the former, are practically unobtainable.

* * *

WORKMEN'S COMPENSATION AND OCCUPATIONAL AND TRAUMATIC DISEASES

BY CHESLA C. SHERLOCK [1]

Under the workmen's compensation acts, diseases may be roughly divided into two general classes: compensable and non-compensable. The most common of the non-compensable diseases are the so-called occupational diseases, which are those arising from causes incident to the workmen's employment, as copper or lead poisoning. As a rule, these diseases are of slow origin and are reasonably sure to occur in certain employments, if followed a sufficient length of time. The authorities are well settled and agreed on the point that they are not "injuries by accident" within the meaning of the compensation acts, and, consequently, are not compensable. The so-called traumatic diseases, however, are compensable. These are defined by one authority as diseases caused by physical injury. While occupational diseases may be due to external conditions, they depend in part on conditions inherent in the individual. Traumatic diseases, on the other hand, are caused ordinarily by external conditions entirely, resulting in physical injury, which, in turn, produces the disease.

The whole theory of recovery under the workmen's compensation acts is based on personal injury by accident arising out of and in the course of the employment. Diseases depending in whole or in part on conditions inherent in the individual are not compensable, unless they are the result of a compensable injury. Traumatic diseases, depending largely or wholly on external conditions and having no reference to the previous condition of the individual or to the employment, are in the nature of injury by accident, and if they can be established as arising, at a time certain and fixed, out of the employment, they are compensable. Among the diseases that the courts have construed as traumatic are: Anthrax, bends or caisson diseases, cancer following blow, heat stroke sustained by steamship stoker, nephritis following working in cold water, nervous shock causing neurasthenia, neurasthenia following fall, overexertion causing cerebral hemorrhage, peritonitis following fall, phlebitis following strain, pneumonia caused by miner's inhaling carbon monoxide generated by explosion, pneumonia following chill resulting from miner's being detained at bottom of shaft by breaking machinery, pneumonia following fall, retinitis in plate printer occasioned by experimental use of bright light, rheumatism following wetting of workman baling out water accumulating in bottom of mine shaft following breaking of pump, and sunstroke.

Hernia may be traumatic, but all hernias are not of traumatic origin. Dr. Oliver J. Fay states that the national insurance bureau of France demands that the following conditions be present in order that a hernia may be adjudged traumatic: (1) There shall have been a direct contusion of the inguinal region, or the work being done shall have required more than usual exertion. (2) The injured man must have been forced to stop work immediately following the accident. (3) He must have been forced to seek medical attention at once, or at most by the evening of the following day. In Germany, the injured man is required to show that the injury received is of a character capable of producing a hernia, and that the hernia appeared suddenly as the immediate result of the accident. Doctor Fay is of the opinion that the forcing of an incipient hernia through the subcutaneous inguinal ring so that a complete hernia results is so serious a happening that a continuance of work is inconceivable, and expressions of pain and a desire to consult a physician are to be considered necessary results. While these conditions apply specifically to hernia, they are equally applicable, in a general way, to all diseases of a traumatic origin. While there is some natural difference in the various jurisdictions, the general consensus of opinion is as stated.

Many of the diseases mentioned in the foregoing list are not ordinarily compensable for the reason that they depend more or less upon conditions inherent in the individual; but under a certain condition they may become compensable. Take, for instance, pneumonia. Ordinarily, it is not a compensable disease, because it is not ordinarily of traumatic origin. In its more common appearances, it depends primarily on conditions inherent in the individual rather than on external or traumatic conditions. Pneumonia, however, in certain instances, changes its character and enters the traumatic class of diseases. There can be no fixed and certain rule in compensation practice. Each case must depend largely on its own circumstances, and for that reason hard and fast rules are not established or entertained in compensation practice. The measuring stick more properly applied in a compensation case where disease is involved is whether or not it is of traumatic origin, or resulting from physical injury. It is safe to say that if such is the case and the physical injury arose through an accident in the course of the employment, compensation is properly payable.

[1] Address: Box 253, Des Moines, Iowa.

* * *

NEW MARKETS AFTER THE WAR

The wholly abnormal conditions under which business everywhere is now conducted lend particular interest to the finding of new outlets for present products and new products for existing plants. To take an extreme case, no one, for example, realizes better than the duPonts that the vast new plants which they have constructed for the manufacture of explosives to meet the requirements of the war will ultimately, and let us pray it may be soon, find their occupation gone. The sagacious officers of this corporation are therefore already turning their attention to the utilization of their plant and special products in the constructive arts of peace. They have begun the manufacture of artificial leather, lacquers, celluloid, picric acid for use in dyeing, heavy chemicals and many individual dyes and intermediates.—*Arthur B. Little, before Canadian Manufacturers' Association.*

* * *

INDEX TO MACHINERY

The yearly index to the twenty-third volume of MACHINERY (September, 1916, to August, 1917) is now ready for distribution, and copies will be sent upon request.

SCREW MACHINE TOOL EQUIPMENT[1]—1

TOOL EQUIPMENT AND ATTACHMENTS FOR THE GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

BY DOUGLAS T. HAMILTON[2]

THE standard tool equipment used on the Gridley multiple-spindle automatic screw machine differs from that used on other automatics in that the tools are designed for use on a flat type of turret; therefore, the standard tools are not provided with shanks, except those that can be most conveniently held in this manner. Turning tools are clamped directly to the turret face, and such tools as drill-holders are held in rigid holders, which, in turn, are clamped directly to the turret. The standard tools comprise spring chucks, feed chucks or pushers, vertical forming tools, blade-type cutting-off tools, drill-, tap- and die-holders, turners, supports, etc. The attachments include high-speed drilling attachments, taper-turning attachments and attachments for automatic dies. Other attachments, of course, are designed special for performing operations that cannot be produced as economically by the use of the standard types of tools.

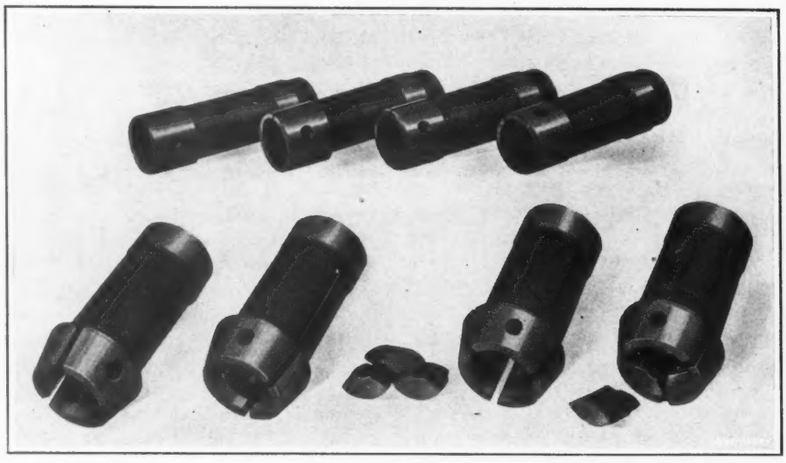

Fig. 1. Group of Spring Collets and Feed Chucks for Use in Gridley Multiple-spindle Automatic Screw Machine

Spring Chucks and Feed Chucks

The spring chucks and feed chucks used on the Gridley multiple-spindle automatic screw machines are of two types: for the ¾-inch machine, these chucks are made solid, whereas for the 1¼-, 1¾- and 2¼-inch sizes, they are provided with bushings, which are made to suit the work that is to be held. A group of spring and feed chucks is shown in Fig. 1, together with some of the bushings that are adapted to them. The illustration accompanying Table 1 also shows the two types of spring chucks used. A spring chuck that is provided with bushings is called a "master," as it can be used for handling a large number of different diameters by substituting bushings of the correct size and shape. The principal dimensions of the spring chucks

[1] For other articles on Gridley automatic screw machine practice, see "Gridley Turret Lathe Equipment," in the August and September numbers of MACHINERY.

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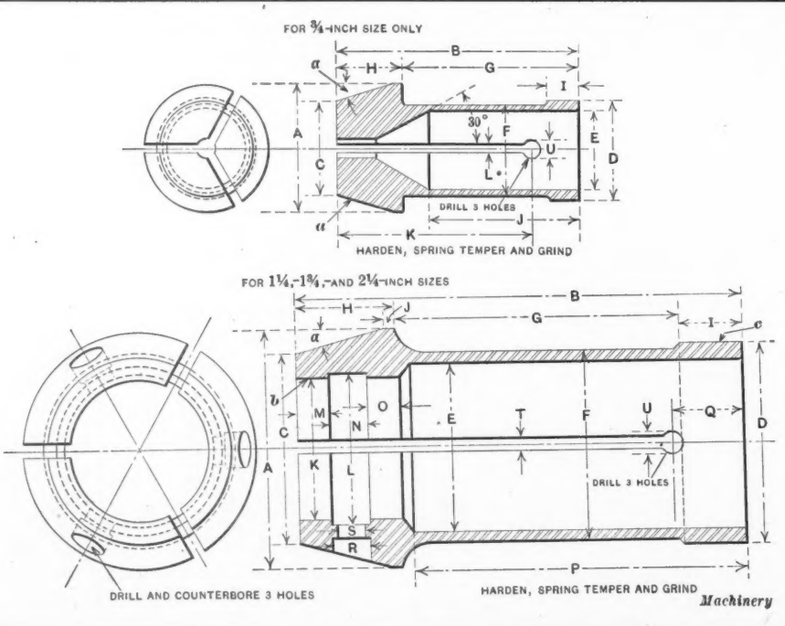
TABLE 1. PRINCIPAL DIMENSIONS OF SPRING CHUCKS USED IN GRIDLEY MULTIPLE-SPINDLE AUTOMATICS


FOR ¾-INCH SIZE ONLY
HARDEN, SPRING TEMPER AND GRIND
FOR 1¼-, 1¾-, AND 2¼-INCH SIZES
DRILL 3 HOLES
DRILL AND COUNTERBORE 3 HOLES
HARDEN, SPRING TEMPER AND GRIND
Machinery

Size of Machine	Dimensions, Inches																					Degrees a,
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
¾	1 1/16	3¼	1¼	1 1/32	1 1/16	1¼	2 3/8	7/8	7/16	2 1/16	2 5/8	1/16	—	—	—	—	—	—	—	—	1/8	15
1¼	2.1538	3 5/32	1.700	1.915	1 9/16	1 7/8	2 5/32	1	1 1/16	3/32	1¼	1 1/32	5/16	3/8	5/16	2 13/64	2 5/32	3/8	17/64	1/16	5/32	14½
1¾	3.0915	6	2.455	2 5/8	2¼	2½	3 1/16	1 5/16	¾	1/8	1 7/8	2 1/16	7/16	½	7/16	4½	1	½	⅜	1/8	¼	15
2¼	3½	5 3/32	2.7966	3	2 11/16	2 15/16	2 31/32	1½	⅞	3/16	2 3/8	2 5/8	9/16	½	9/16	3¼	1 1/16	½	⅜	1/8	¼	14½

are given in Table 1. These chucks are made from a special grade of steel, which will take a spring temper; after machining, they are hardened and spring-tempered, and then ground at *a*, *b* and *c*. At *A* in Fig. 2 is shown a sectional view of a spring chuck, which illustrates how the bushings are held in place. It will be noticed that the bushings are held in place by means of fillister-head screws fitting in counterbored holes in the three sections of the spring chuck.

The feed chuck used in the ¾-inch size of machine, as shown in the illustration accompanying Table 2, is also made solid, whereas for the 1¼- 1¾- and 2¼-inch sizes it is made so that bushings can be added to accommodate various sizes and shapes of bars. These bushings are shown assembled in the feed chuck *B*, Fig. 2; they are held in place by cone-head screws, and fit in a recess, so that the drawing action of the chuck on the bar will not loosen them or disturb their correct longitudinal position. Table 2 gives the principal dimensions of both the solid and master type of feed chucks for all sizes of Gridley multiple-spindle automatic screw machines. The feed chuck is also made from a special grade of steel that will spring-temper well, and before hardening and spring-tempering, is closed in to give it the desired grip on the work.

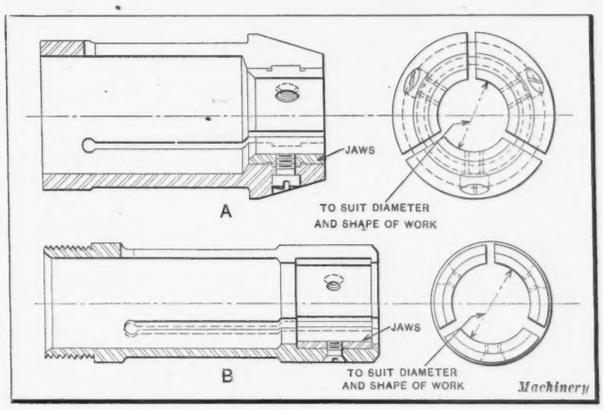


Fig. 2. Diagram showing Method of holding Bushings in Spring Collet and Feed Chucks

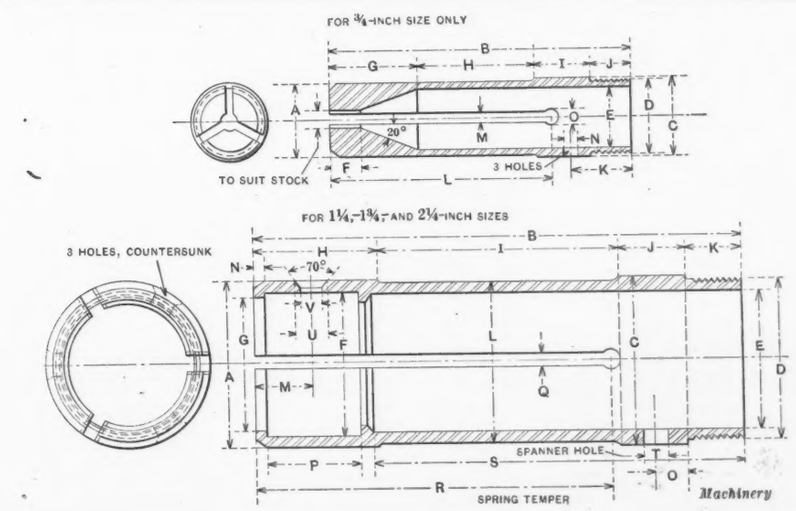
Forming and Cutting-off Tools and Holders

The type of forming tool generally used on the Gridley multiple-spindle automatic screw machine is the vertical forming tool; this is held in the holder by a dovetail projection. The type of forming tool-holder used is shown in Fig. 3, fastened to the forming slide. Reference to this illustration, and also to *C*, Fig. 4, will show that the holder is split, and is clamped to the forming tool by means of two fillister-head screws. This tool, it will be noticed, is held by friction, and an adjusting screw in the bottom of the tool, so that a perfect fit must be obtained between the tail of the tool and the slot in the holder. The forming tool is sharpened by being ground on the top face; the grinding should be so done that the corrections made on the tool for the angular position are not disturbed. This point is important, if it is desired to retain the diameter laid out on the tool when it is made. In the forming of some materials, such as cold-rolled steel, it is occasionally necessary to provide a top rake. This changes the difference between the diameters produced on the work, and allowance must be made for the amount of top rake given, when laying out the tool. Forming tools of the type shown in Fig. 3 are generally ground on the cutting face after hardening, so that warpage or other defects are removed. The methods used in grinding this type of tool were described in detail in the article "Making Vertical Forming Tools," in the December, 1914, number of MACHINERY.

When only a simple form is required, a tool-holder like that shown at *A*, Fig. 5, is used. This holder is clamped to the forming slide in the usual manner, and carries a single-blade forming tool, which is held in place by two screws and rests on an adjustable wedge. One screw backs up the wedge and the other the forming tool. This type of forming tool is made for either right- or left-hand work, as illustrated at *B* and *C*, respectively.

Fig. 6 shows a special cut-off tool-holder, which is used principally for cutting off washers or similar shaped work. This holder is arranged to carry five cutting-off blades, enabling

TABLE 2. PRINCIPAL DIMENSIONS OF FEED CHUCKS USED IN GRIDLEY MULTIPLE-SPINDLE AUTOMATICS



Size of Machine	Dimensions, Inches																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
¾	31/32	4 1/16	1 1/32	0.920×32 P. L. H.	25/32	—	1 3/16	1 9/16	3/4	9/16	13/16	3	1/8	3/16	1 3/16	—	—	—	—	—	—	—
1¼	1 7/32	4 7/16	1.555	1 7/16×20 P. L. H.	1 3/16	1 3/16	1 1/16	1 5/16	2 1/8	3/8	5/8	1 13/32	1/8	3/32	1/4	1	1/8	3 5/16	3 1/16	1/4	27/64	3/16
1¾	2 3/16	6½	2 3/16	2 1/16×24 P. L. H.	1 13/16	1 7/8	1 11/16	1 5/8	3 1/4	7/8	3/4	2 1/16	3/8	1/8	7/16	1½	1/8	4 3/4	4 15/16	5/16	7/16	5/16
2¼	2.560	7	2.620	2 1/4×24 P. L. H.	2 1/8	2 1/4	2 1/8	2 1/4	3	3/4	1	2 3/8	7/8	1/8	3/8	1½	1/8	4 15/16	—	5/16	33/64	5/16

five washers to be cut off at one time. The die-spindle is arranged with a stripper rod, as shown, to prevent the washers from wedging in between the cutting-off blade, and when the tool-slide retreats the washers are removed from this rod by a stripping plate held on the side of the holder carrying the cutting-off blades.

When the amount of forming to be done is considerable and consumes a large proportion of the cutting time, the cut is sometimes divided between two forming tools. This is accomplished by the use of the double tool-holder shown at *D*, Fig. 4, at *E*, Fig. 5, and in Fig. 7. The last illustration shows the method of carrying the oil or cutting compound to the forming tools. With this double tool-holder, the tool in the first position (the lower tool) is used for roughing, and when the bar is indexed to the second position it is finish-formed by the top tool. In this way the forming cut can be divided between two tools; the production is thereby increased, and the greatest degree of accuracy is obtained.

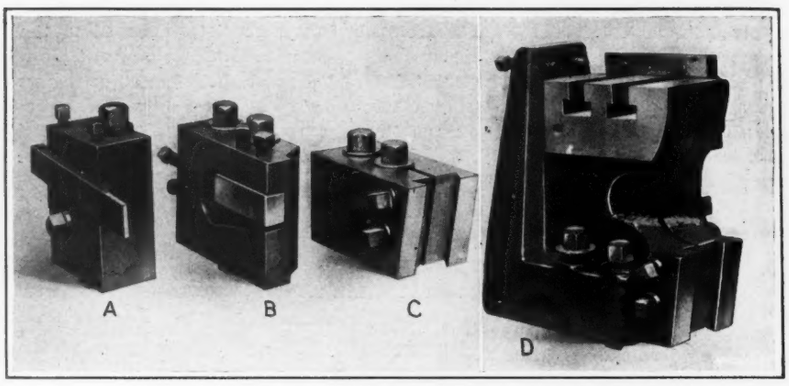


Fig. 4. Forming and Cut-off Tool-holders

The five standard sizes of dovetails used on the vertical type of forming tool are shown in Fig. 8. The size of dovetail used on the tool is governed by the width or depth of the form. The wider the form, of course, the wider must be the dovetail to furnish the required support for the tool. The double type of forming tool-holder, as shown in Fig. 7, is cast solid with the main holder, and in order to accommodate different widths of dovetail, shanks are made for the ¾-inch, 1¼-inch, 1¾-inch and 2¼-inch machines in the sizes shown at *A*, *B*, *C*, *D* and *E* in Fig. 8. The dovetails are made with the regular 60-degree angles, and range in width from 7/16 to 1⅝ inch, measured at the narrow part. All are tapped for a vertical adjusting screw (except the smallest size shown at *C*), which provides convenient means of adjustment in relation to the center of the work and gives extra support when heavy forming is being done. This latter is an important consideration for the first forming operation, in which generally the greater amount of stock is removed. The typical set-up at *E*, Fig. 5, shows the relation of the two tools clearly.

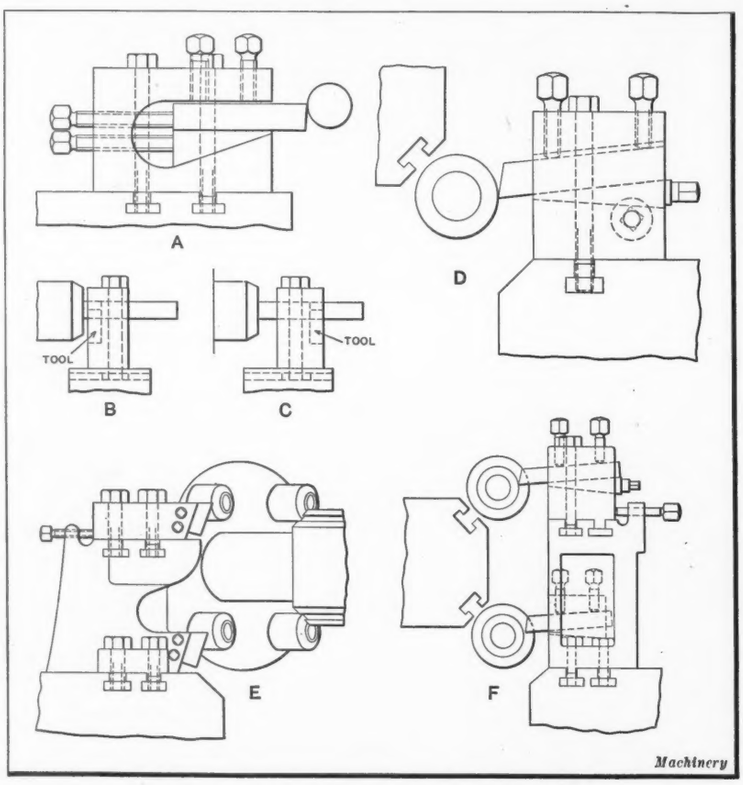


Fig. 5. Diagram showing Forming and Cut-off Tool-holders

When the shape and diameter of the part to be formed is such that a circular forming tool can be used to better advantage than the dovetail type, the special double-deck forming tool-holder shown in Fig. 9 is used. This holder is fastened to the forming slide in the usual manner, and carries two shank holders, which are arranged to carry circular tools. The circular type of forming tool is only recommended for light forming.

The cutting-off tools used on the Gridley multiple-spindle automatic are of the blade type, and are held in a holder of the type shown at *A*, Fig. 4, and at *D*, Fig. 5. This holder is clamped to the cutting-off slide by two screws, the tool resting on an adjustable wedge, as shown. As the cutting-off tool is seldom used for anything but plain cutting off, the ordinary type of forged tool or blade can be used. When it is necessary, however, to chamfer the end of the work, this can best be done with the forming tool, keeping the cutting-off tool plain. When there are only a few operations to be performed on the part being produced, consisting chiefly of forming and cutting off, it is possible to use the arrangement shown at *E* and *F*, Fig. 5, having forming and cutting-off tools working in all four positions. For instance, the first and second positions can be used for forming, and the third and fourth positions for cutting off.

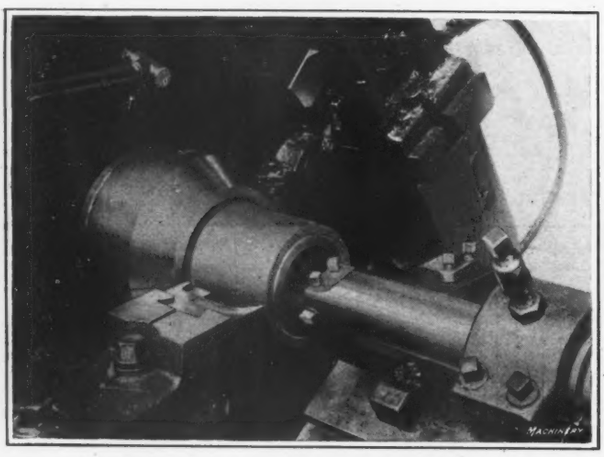


Fig. 3. View showing Dovetail Forming Tool at Work

Turners and Back-rests

The design of the Gridley turret is such that it is possible to use a type of turning tool that is more rigid than the well-known box-tool, and that consequently cannot be described by that term. Fig. 10 shows a group of standard turners and supports. The holder is made to straddle the corner of the

turret, and is clamped to the latter by two T-bolts. The turning tool and the roll supports are held in blocks that are capable of being adjusted. Fig. 11 shows most of these holders in diagrammatic form. It will be seen that the turning tool is of the tangent type. With the exception of the lower one, the turners shown in Fig. 10 are of the plain type, and are used for general straight turning. When more than one shoulder is to be turned down at one time, the multiple type of turner shown is used. This tool will be described later.

When heavy forming is being done from the forming or cutting-off slides, or when a rigid support for the work is necessary, back-rests are used. Two of these are shown at *A* and *B* in Fig. 11, and are for right- or left-hand work, for use in the second position. The back-rests can be used in connection with the double-deck forming tool-holder when

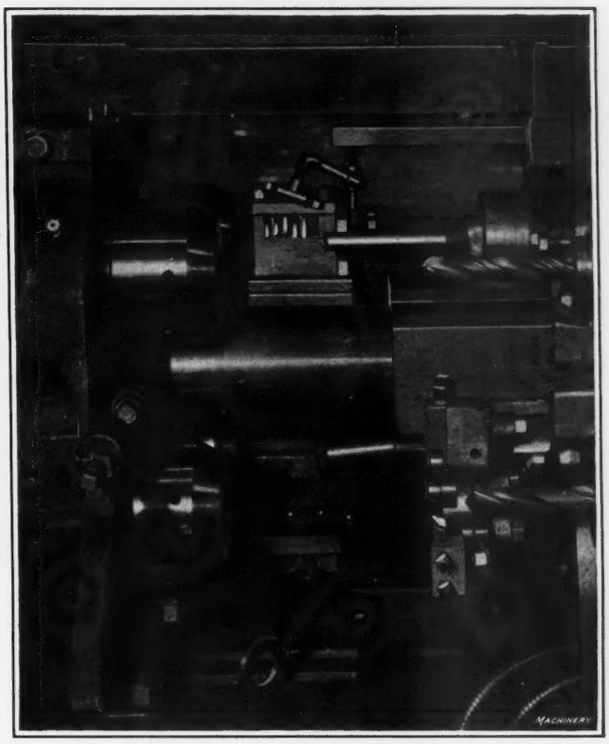


Fig. 6. Multiple Cutting-off Tool-holder used for cutting Five Washers simultaneously

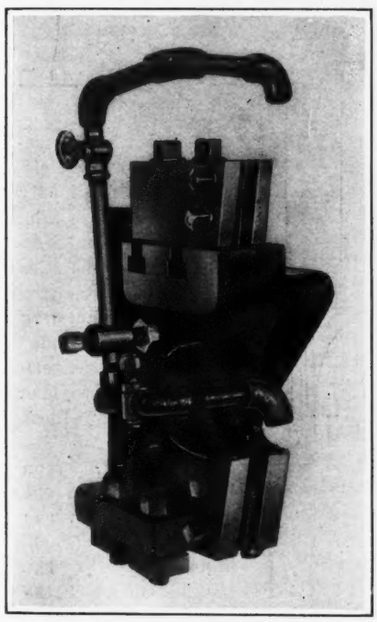


Fig. 7. Double-deck Forming Tool-holder

it is necessary to support the work against the thrust of the cut, the work previously having been reduced by the roughing-forming tool. At *C* is shown another type of roller back-rest, both for right- or left-hand work, for use in the first or third positions.

The capacities of the standard roller and plain back-rests are given in Fig. 12. *A* and *B* illustrate a roller and a plain rest for use on the ¾-inch machine. It will be noticed at *A* that the smallest diameter than can be supported with the rollers 1/32 inch apart is 0.303 inch; whereas, with the rollers touching, the smallest diameter that can be supported is 0.258 inch. With the plain type of back-rest shown at *B*, the smallest diameter that can be supported with the rests 1/32 inch apart is 0.169 inch; whereas, with the supports touching, the smallest diameter that can be supported is 0.125 inch. As shown at *C*, on the 1¼-inch machine, the smallest diameter that can be supported with the rolls 1/32 inch apart is 0.484 inch, and with the rolls touching, 0.440 inch. With the plain type of rest shown at *D*, the smallest diameter that can be supported with the rolls 1/32 inch apart is 0.294 inch; closed, 0.250 inch. On the 2¼-inch size of machine, shown at *E*, the smallest diameter that can be supported with the rolls 1/32 inch apart is 0.561 inch, and with the rolls touching, 0.516 inch. When requirements demand it, special roller rests are made.

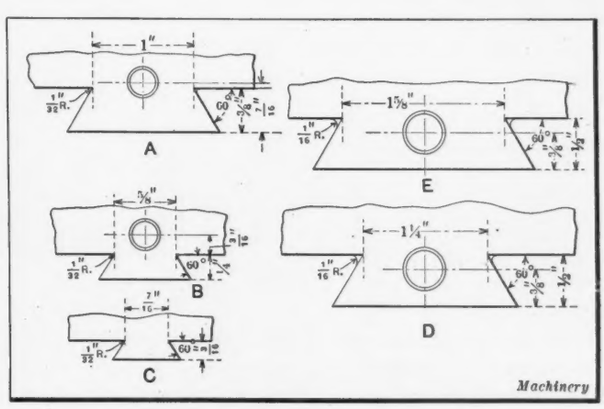


Fig. 8. Diagram showing Proportions of Dovetails for Straight Forming Tools for Use on the Various Sizes of Machines

Stud Turner

A common type of stud turner for use on the Gridley automatic, adapted for use in the second or third position, is shown in Fig. 10 and diagrammatically at *E* in Fig. 11. This stud turner is provided with holders for retaining three turning tools, each one being individually adjusted by means of a collar-head screw. The work is supported by a combination back-rest, made double-ended and holding four rolls. These back-rests are adjustable along the holder and can be placed to support the work at the point or points desired. With a stud turner of this type, it is possible to produce more than one diameter at one traverse of the turret, and thus produce in one cut multiple shoulder studs, shafts, etc. Fig. 13 shows a recessing tool-holder at the left-hand side, which is operated by the pusher shown at the right, held on the forming slide. Fig. 14 shows a swinging stop, which is held in a bracket on the main frame of the machine, and is operated by a cam disk on the main cam drum in the 1¾-inch machine. On the other sizes the stop is operated by a cam carried on one of the miter gears that actuate the cut-off slide.

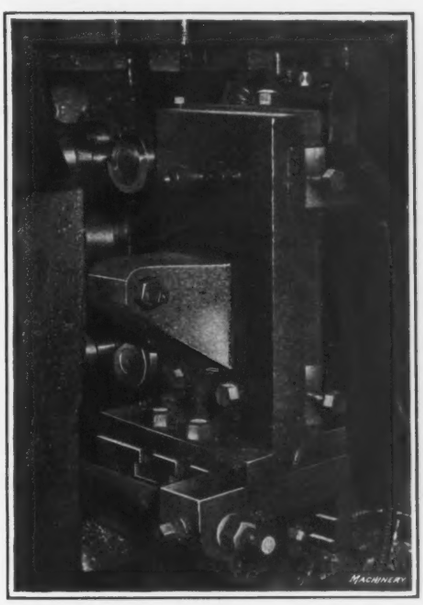


Fig. 9. Type of Double-deck Holder used for Circular Forming Tools

Tool-slide Tool-holders

The standard tool-holder used on the tool-slide carries such tools as drills, reamers, boring tools, knurl-holders, etc. This form of holder is

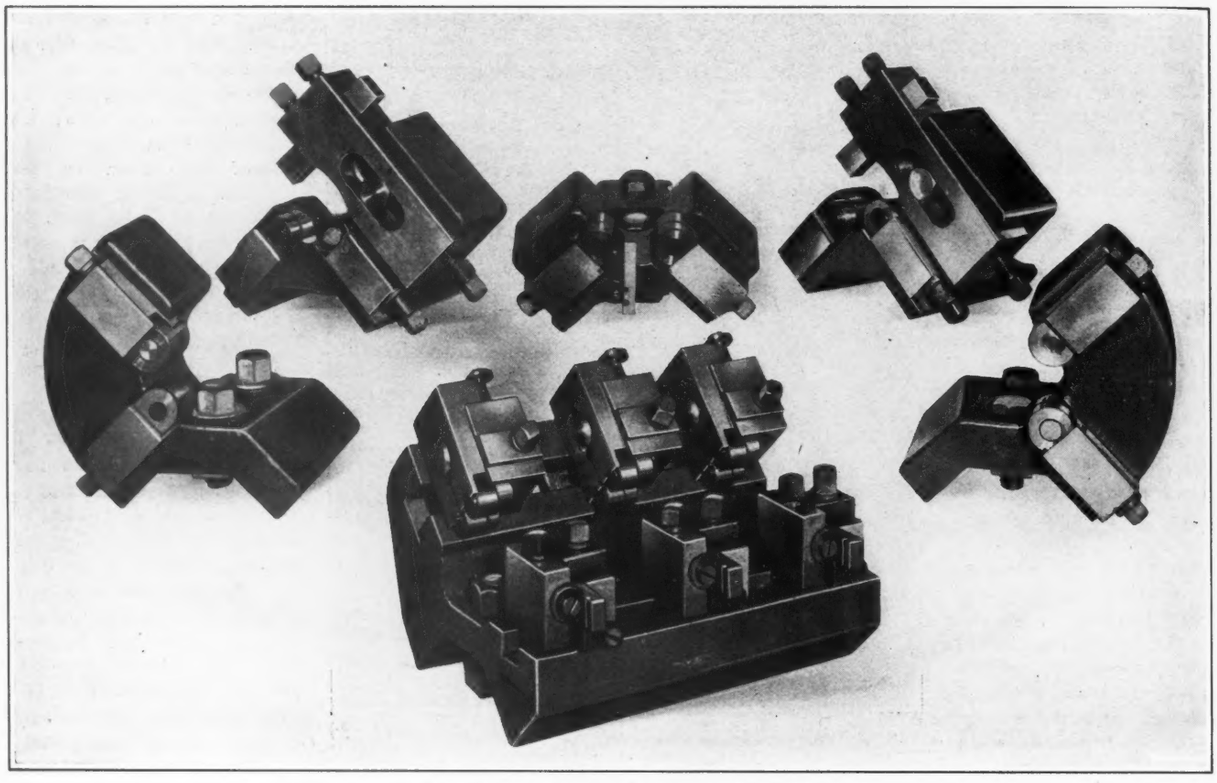


Fig. 10. Group of Supports, Turners, and Stud Turners

shown in Fig. 15, and in diagrammatic form in connection with Table 3, which gives the principal dimensions of the tool-holder, namely, the length of the base, length of the bushing, the distance from the front of the bushing to the edge of the base, and the diameter of the hole. The last dimension corresponds to the shank of the tool that is to fit into it when no bushing is used. This standard holder can be used in all four positions on the 1¾-inch multiple-spindle machine. All other sizes of machines have special tool-holders for the fourth position; but the fourth position tool-holder is not furnished unless specially ordered. The tool-holders are clamped to the tool-slide by means of T-bolts, which permit them to be adjusted to the desired position. The tool is clamped in the holder by means of two collar-head screws, the upper part of the holder being split to allow for expansion and contraction.

* * *

Although 75 per cent of the 1916 output of crude rubber was produced within the British Empire, the United States manufacturers took about 62½ per cent of the total output, while British manufacturers took only 12 per cent.

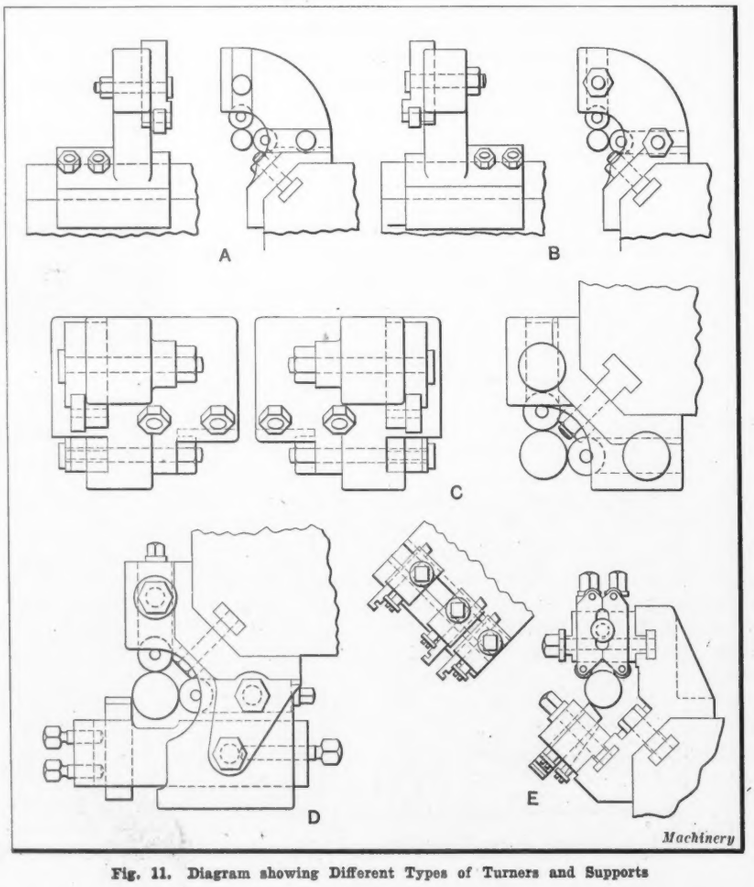


Fig. 11. Diagram showing Different Types of Turners and Supports

LABORATORY FOR TESTING AEROPLANE MOTORS[1]

In an aeroplane fight, victory is with the aviator whose machine can attain the greatest speed and reach the highest elevation. At present an aeroplane can reach a height of only about 23,000 feet, on account of the thin air and intense cold, and in order to overcome these difficulties the United States government is building the first "altitude" laboratory to experiment with aeroplane motors under these very conditions. The laboratory will soon be completed on the grounds of the Bureau of Standards, Washington, D. C. The chamber in which the motors will be tested is about twelve feet long, six feet wide and seven feet high. It is enclosed by reinforced concrete walls built to withstand a pressure of one ton per square foot on the outside, to prevent them from being crushed by the weight of air at the earth's surface, when the air inside has been rarefied to the thinness of an altitude of about 20,000 feet. This room

[1]Abstract of an article published in the New York Times Magazine, September 9, 1917.

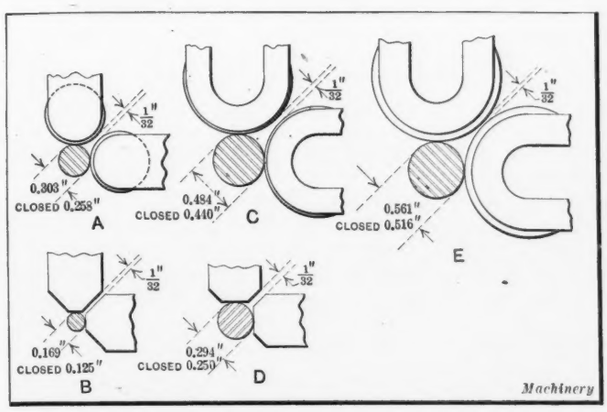


Fig. 12. Diagram giving Capacities of Solid and Roller Rests

will contain refrigerator coils to absorb the heat from the exposed parts of the engine, and fans for circulating the cooled air over the engine and past the cooling coils. The pressure in this chamber can be maintained at any desired point down to one-half atmosphere by means of an exhaust blower that is capable of drawing away 1600 cubic feet of air per minute, which takes the exhaust from the engine, as well as any air leaking into the chamber, and discharges it outside. The power from the engine is absorbed and measured by means of an electro-dynamometer, mounted outside the vacuum room. The behavior of the engine at all speeds can be measured at

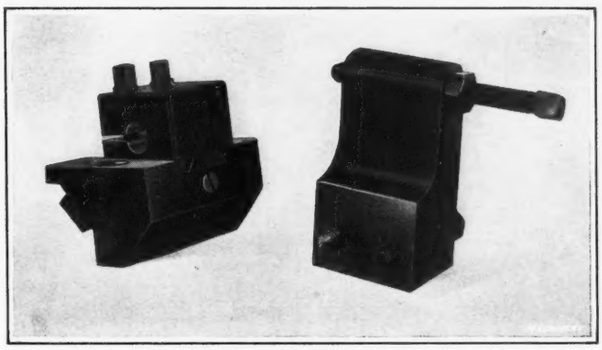


Fig. 13. Recessing Tool-holder and Pusher used for operating it

will, making possible a systematic study of the performance. Provision is made for supplying air to the carbureter not only at any desired pressure, but also at any desired temperature by means of a twenty-four-ton refrigerating plant. Among the points to be investigated with the equipment are the effects of different grades of fuel. This laboratory offers a complete equipment for investigating the performance of aeroplane engines up to about 300 horsepower and of many types of much higher power at all practicable altitudes and temperatures.

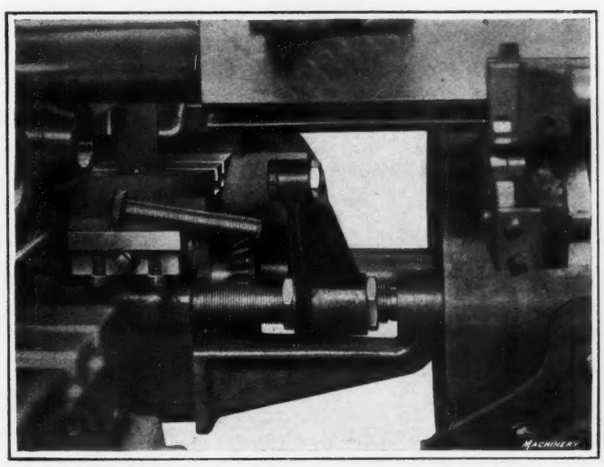


Fig. 14. Swinging Type of Stop used on 1¾-inch Machine

MODERN LOCOMOTIVE PRACTICE[1]

Comparatively few locomotives are now built without a fire-tube superheater, as the economy resulting from the use of this device is marked. To reduce the fuel consumption further, the use of brick arches supported on water tubes is common, as modern improvements in the design of the arches have made their use practical. On road locomotives the outside valve gear of the Walschaerts type is used almost entirely, and is also used on some switching locomotives. Accessibility, better distribution of steam and freedom from breakdowns make outside gearing desirable. The majority of engines now built are so heavy that the usual reversing mechanism is not suitable, and power reverse gearing has been introduced with satisfactory results. Pneumatic fire doors relieve the fireman of much work and greatly reduce the time that the door is kept open. It is now the practice to have outside steam pipes to the steam chest, instead of having them placed in the smoke-box, thus eliminating to a large extent trouble from leaky joints, and giving easier access to the smoke-box appliances. The advent of long freight trains called for air compressors of greater capacity, and two single-stage pumps, or one compound pump, are used. On some large locomotives mechanical stokers have been installed and are doing very good work.

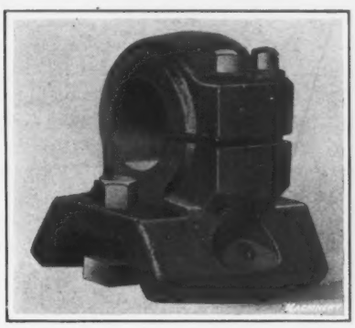
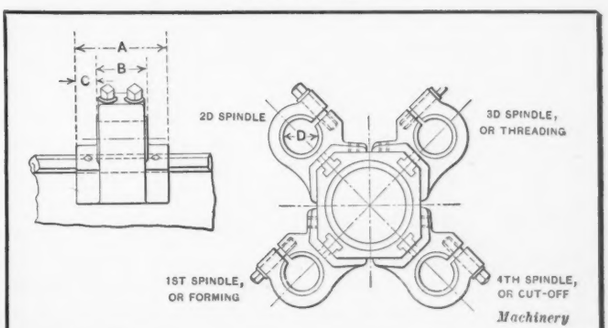


Fig. 15. Standard Tool-holder used on Tool-slide

The tendency today is toward locomotive tenders of large capacity. To save labor and because of legislation, tenders are now constructed with coal hoppers designed so that the coal will automatically be placed within easy reach of the fireman.

TABLE 3. PRINCIPAL DIMENSIONS OF TURRET TOOL-HOLDERS



Dimensions, Inches	Machine Sizes			
	¾-inch	1¼-inch	1¾-inch	2¼-inch
A	3 7/8	3 3/4	5	5 1/2
B	2	2	2 1/2	2 1/2
C	15/16	7/8	1 1/4	1 1/2
D	1 1/2	2	2	2 1/2

Special attention has been given for a number of years to truck design, with a view to eliminating dangerous roll at high speeds. In many derailments the forward tender truck is the first to leave the track. Comparatively slight depressions in the track may set up a rolling of the tender, which, accompanied by a reverse roll of the locomotive, will cause the forward tender wheels to jump. The connections between the locomotive and tender also have a bearing on this, and one connection has been designed which is a vast improvement over anything used before.

[1]Abstract of a paper read before the Minnesota Section of the A. S. M. E., March 10, 1917, by T. A. Foque, Minneapolis, Minn.

THE FUTURE OF THE MACHINE TOOL BUSINESS IN RUSSIA

CONDITIONS THAT WILL CONFRONT THE MANUFACTURER AND DEALER AFTER THE WAR

BY A. M. PESKINE [1]

THE purpose of this article is to give in concise form some ideas that may be of interest to American manufacturers in regard to the sales policy of machine tool builders in Russia in the future. The writer's principal reason for going into this matter is that during frequent conversations with American machine tool manufacturers on the subject the question most frequently asked has been: "Can you recommend to me someone who would make a good agent for my concern in Russia?" This question has been asked so often that it appears to be the opinion of the majority of manufacturers that all they need in order to sell their product in Russia is the right kind of agent, and that, provided they can get such an agent, everything will run smoothly. This is by no means the case, and the entire question is a somewhat difficult one, depending not only upon the agent himself, but also upon other matters that will be mentioned later.

There have been many radical changes in the selling of machine tools in Russia, and, therefore, a change should be made not only as far as the agent is concerned, but also in the entire system and methods of selling. There are several points that must be considered in this connection: First, the changes in the American machine tool market; second, the fact that the buyer of the present time and the buyer in Russia after the war should be two distinct types of men; third, the new method that should be applied when selling machine tools in Russia, due to the two radical changes mentioned above.

In taking up this matter in detail, the writer would first call attention to the fact that before the war American manufacturers did not show much energy in the matter of selling their machine tools generally in Europe and principally in Russia. There is no exaggeration in saying that American manufacturers do not understand even at the present time the proper methods used in selling machine tools in Russia, and, in fact, they have no experience whatsoever as to actual conditions. This may sound strong, yet it is the truth.

Before the war, agencies for all the largest machine tool concerns were given to a small number of large machinery dealers, who were handling all the sales. The American manufacturer, as a rule, did not take pains to ascertain whether the dealer in Europe was doing his utmost to secure all the business possible. He was generally well pleased if the European dealer would send in a few orders from time to time. Whether these orders represented the maximum that might have been obtained under the circumstances has never been determined. How little the average machine tool manufacturer understood the details of his sales campaign in Russia can best be shown by the fact that some of the machinery dealers in Europe were handling machine tools of one and the same kind, yet made by three or four different manufacturers who are strong competitors in this country. Such conditions should never be permitted, and the American machine tool manufacturer should look seriously into the details of the methods employed in the selling of his machine tools in Russia.

German Competition

The matter of competition with German manufacturers is of sufficient importance to be considered under the other factors that affect the sales campaign. Before the war it was necessary to take into consideration these German machine tool manufacturers, although their tools were always poor copies of machine tools made in this country. The writer recalls from his own experience how difficult it was for him a few years ago to sell a few Lodge & Shipley lathes to a machine shop in the southern part of Russia, just because one German manufacturer from Hamburg was selling a poor copy of the same lathe at a much lower price than the American tool.

Naturally, as soon as the war is over, German competition will be much stronger, and due preparation must be made to meet it, for the reason that during the entire war German industries have developed rapidly, due to the exigencies of the situation. Manufacturers in Germany have not been importing any machine tools from abroad, and as they have been obliged to produce large quantities of war material, it has been necessary for them to develop superior types of machine tools in order to handle their production. It is probable that the developments in machine tools have kept pace with some of their achievements in industrial chemistry.

Changes in American Machine Tool Market

Since the beginning of the war many new concerns manufacturing machine tools have been formed in the United States, and no doubt a considerable number of these will pass out of existence at the close of the war. Many of these machine tool builders, however, have developed to such an extent that they will continue to produce, as they have invested large amounts of money in buildings and equipment, and on account of the huge war orders they have secured, have paid comparatively little for what is usually the largest expense of every new enterprise, *viz.*, the experimental stage. It cannot reasonably be expected that these new firms will give up the results of their work, and, therefore, this competition is a factor in America and will be also a factor in the Russian market. The old and well established machine tool concerns are often inclined to believe that they have no competition whatever. It is well to keep in mind the old business rule, "Better overestimate a competitor than underestimate him."

The Russian Buyer after the War

In taking up these points in detail, let us consider why the Russian buyer after the war will be different from the former buyer. During the war a large number of Russian engineers came to this country. All the government controlled concerns sent their inspectors and engineers, and many private concerns followed their example. If, therefore, we take it for granted that 50 per cent of these men have been taking advantage of their opportunities properly, this experience must eventually bear fruit. All these technical men have become more or less acquainted with American methods of manufacture and management. Many of them have visited American machine shops, and through their duties as inspectors have had plenty of opportunity to become thoroughly familiar with the most minute details of manufacture. It follows that if these men are spread through Russia in the future, and if they are factors in the buying of machine tools, they will be in a position to know what is required. The time has passed when the man was called a good salesman because he could sell a shaper where the work called for the installation of a lathe. The buyer in Russia at the present time understands that there is more than one concern in America manufacturing and selling certain types of machine tools. A short time ago, however, the word "milling machine" or "turret lathe" recalled to the Russian buyer's mind only the name of the best known concern making the one tool or the other. Now since a large number of Russian engineers have been visiting the different factories and have seen the different makes of machine tools, they have become familiar with the different concerns manufacturing various types of machines.

The writer is still receiving proposals from machinery dealers with circulars attached on which the manufacturer's name has been blotted out; but in most cases he has made inquiry of the manufacturer direct. The Russian buyer has now become familiar with the prevailing prices of machine tools, and this fact is of extreme importance for future business, because Russian machine tool dealers have been taking advantage of this lack of knowledge on the buyer's part to a considerable extent. Naturally, the prices during the war are much higher than normal, yet due allowance can be made so as to take the changes of price into consideration. Aside from this,

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Russian buyers have been in this country long enough to become acquainted with manufacturers and many other people in the trade who are able to post them on current prices.

Russian industries have never been so much in need of suitable methods for interchangeable manufacture as during this war. The enormous demand for war material has revolutionized the methods in the majority of Russian machine shops, and without doubt has been as deciding a factor for these industries as automobile manufacture has been for American machine shop practice. All the above matters must be considered in taking up methods of selling to be applied to American machine tools in Russia.

Methods of Selling in Russia

As previously stated, all American machine tools before the war were handled by a few machinery dealers in Russia. To these dealers due credit must be given for the great persistency applied in their selling campaign. They were spending a great amount of money for printing beautiful catalogues, which were frequently produced at a cost of $10 to $15 each, yet all these catalogues were given out free upon request. The salesmen themselves were recruited from people of good standing, and a great deal of attention was paid to their manners. The offices and show rooms were furnished in the most luxurious way, and much attention was paid to appearances generally, no expense being spared to make a good showing. The writer knows absolutely that the sales costs to some machinery dealers ran as high as 18 per cent. All of this would have been very effective, providing more attention had been paid to the professional training of the salesmen.

Unfortunately, this phase of the situation was completely ignored. Personal connections and friendships among business men were appreciated more than engineering knowledge. It is true that once in a great while a salesman was enabled to obtain a talking point about the tools he was selling from American experts who were sent to Russia. Still, while talking points are important assets for a salesman who has the necessary knowledge of machine tools, without that knowledge talking points are good only during the first call. After a few visits the salesman has run out of facts and is obliged to recall obsolete and old-fashioned terms like "best in the world," or "best on the market," or "most reasonable," etc. It will be seen, therefore, that if a thorough knowledge of tools was important before the war, it is imperative now. Less attention will have to be paid to appearances and more to essential mechanical points.

The fundamental question of selling may now be taken up. Is it really possible to find a man who knows every kind of machine tool thoroughly? The answer to this question is, of course, that such a man is almost impossible to find. In the United States no attempt is made to find a man with such an amount of knowledge, but the matter is arranged by having specialists for certain kinds of machine tools. These specialists sell one type of tool and one only. It is the belief of the writer that the time has come when Russia will need salesmen highly specialized in one particular line. His advice to large American concerns is to start independent sales offices in Russia. This method, without doubt, has a bright future. In the first place, thanks to the comparatively small variety of tools that any one concern can produce, it is a simple matter to be conversant with the entire line. Therefore, the proper kind of salesmen can be selected without difficulty, and their training is comparatively simple. In the second place, the price for one kind of machine tool will be the same for everybody, and there will be no complaints from the customers as to differences in price. In the third place, the sales offices will be in direct touch with the buyer, which is much better for both. The buyer will be able to come personally to the sales office and ask certain questions about details with which he is unfamiliar. For example, in an office for selling automatic machinery, the buyer will find samples of work produced on automatics and will be able to judge for himself the kind of machine best suited to his requirements.

It is surprising that large machinery concerns making lathes, milling machines, small tools, and the like, should concern themselves at all as to whom to appoint as their representative in Russia. The best solution of this problem is to start a sales office of their own. It is unnecessary to consider the question of details for an organization of this kind. I would suggest, however, that there should be a few Americans working together with an experienced man familiar with local conditions. The only drawback to this arrangement would be the comparatively large expenditure, so that only concerns having a large volume of business could probably afford it. For concerns of smaller size, the most practical solution of the problem would be one sales office for a number of manufacturing concerns. The essential point in this plan is that a number of concerns making different types of tools, each type being of approximately equal importance to the average shop, should combine and start a sales office. All the advantages of the first method mentioned are found with the second, and some additional benefits. The expenses are greatly reduced for each partner of the sales office, and the enlarged organization is of assistance in securing additional information relative to new business. Suppose that one salesman is selling a planer. It is easy for him to ascertain whether any other machine tools are required, and he can immediately notify the office in regard to it, so that another salesman will be put in touch with this manufacturer. The second method of selling is a great advantage to a concern making special machinery, for the reason that the amount of business is too small for it to afford an office or a direct representative, yet by combining an office with some other manufacturer the advantages of a separate organization are gained.

In deciding which of these two methods would be more advantageous in Russia, the American manufacturer must make up his mind in regard to the matter of credits and collections. This question was not taken up seriously by American manufacturers before the war because their product was handled entirely by the dealer. After the war, however, it will be of the greatest importance. The writer believes, however, that this matter will not be as serious as it has been in the past, as many American banks have opened branch offices in Russia. It can also be stated from the writer's own experience that, although machinery dealers have extended long term credit to the buyers in Russia, the percentage of actual loss has been small. In the event, however, that an American manufacturer positively refuses to handle the account of a Russian customer, nothing remains to be done except to use the old method of selling, which means giving the agency to any kind of machine tool dealer in Russia. This brings us back to the first question once more.

Selection of the Dealer

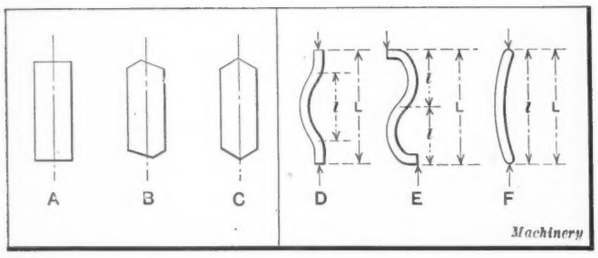
In the first place, the machinery house should be one specializing in selling machine tools only without any side lines whatsoever, and should employ salesmen who, by training and experience, are fitted to sell high-grade machines only. It is a well-known fact that unless a salesman is accustomed to sell only high-grade tools, if he is unable to close a sale, he will invariably follow the line of least resistance and try to substitute an inferior tool. There should be an iron-clad rule that a salesman must sell his own machine or nothing.

Now in regard to the financial end of the business. Machine tool manufacturers in this country are likely to overestimate the value of large financial assets of concerns selling machine tools abroad. It should be emphasized that dealers in machine tools need a certain minimum of working capital in order to carry on their business, but this minimum is all that is necessary. It is useless to cater to concerns that work with very large capital, because such a condition places a dealer at the mercy of other firms backed up by large banking interests. Bankers are poor partners for machine tool dealers, as their desire is for large transactions and quick returns, and they overlook the importance of establishing a trade, failing to realize that a trade once established is a great asset. The banker is eager to throw his money into entirely different channels when he finds that he is obliged to wait a long time for settlement, while a specialized machine tool dealer who has nothing else in which to invest his money will have more patience, as he knows good times follow slow times in the machinery business. Furthermore, a machine tool dealer will continue to work in one direction regardless of the favorable or unfavorable conditions of the money market.

COLD-HEADING OF WIRE[1]

COMPARATIVE LENGTHS OF WIRE UPSET UNDER DIFFERENT CONDITIONS

BY ROY H. SMITH[2]



Figs. 1 and 2. Different Types of Cut-offs and how Each tends to bend in cold-heading

COLD-HEADING of wire is essentially a modern development. It is true that cold-heading, in one form or another, has been done for a great many years, but real progress dates from the advent of a good quality of open-hearth steel which can be bought for a moderate price. The process of cold-heading is steadily gaining in importance, and every year sees the production of some new parts by this method. When wrought iron was the only wire obtainable, satisfactory rivets and screw blanks were made by the cold-heading process; and at the present time there are still some buyers who insist upon having rivets of genuine Swedish iron. The pioneers who first realized the possibilities of working steel wire in cold-heading machines spent many thousands of dollars in converting good material into scrap. For a number of years the writer has been connected with the cold-heading industry, and it was with great interest that he read MACHINERY'S Reference Book "Cold-heading." In one of the introductory paragraphs of this pamphlet, under the heading "Principles of Cold-heading," the following statement is made: "These three simple experiments outline the principles in cold-heading." This statement is, of course, very broad and apparently was not intended to be taken literally; yet the real principles involved in upsetting a piece of wire are so often confused or ignored that a more accurate analysis of existing conditions would apparently be worth while.

In beginning a study of the theory and practice of cold-heading, it is essential to keep clearly in mind the fact that theoretically a piece of wire—no matter whether it is long or short—should upset uniformly when subjected to compression. Practice has shown, however, that when the length of the wire is great in proportion to its diameter, there is a tendency for the wire to bend laterally, instead of being upset to the desired form. The trouble encountered from the buckling of blanks in automatic cold-heading machines is probably greater than that experienced from the tendency of any other form of strut to buckle. The reason for this is apparent from the following considerations:

1. A large number of cold-heading machines are run without any adequate straightening device; in other words, wire comes to the header in the form of a coil and is fed into the header with a slight initial bend. When a straightening device is used, it may safely be said that this initial bend is not entirely removed from the wire before the attempt at upsetting is made.

2. Ordinary rivet wire is drawn from rods that are frequently considerably out of round, the result being an appreciable difference in the hardness of the metal at different points on the surface of the wire. In itself, this would be sufficient to result in one side of the wire failing before the other side reached the elastic limit.

3. Unevenness of the cut-off or inaccuracy in setting up the dies produces an eccentric loading, and as shown by Goodman in his "Mechanics Applied to Engineering," this increases the stress in the material. In fact, where the loading deviates from the center of gravity of the section by an amount equal to one-eighth of the diameter, the magnitude of the stress is doubled.

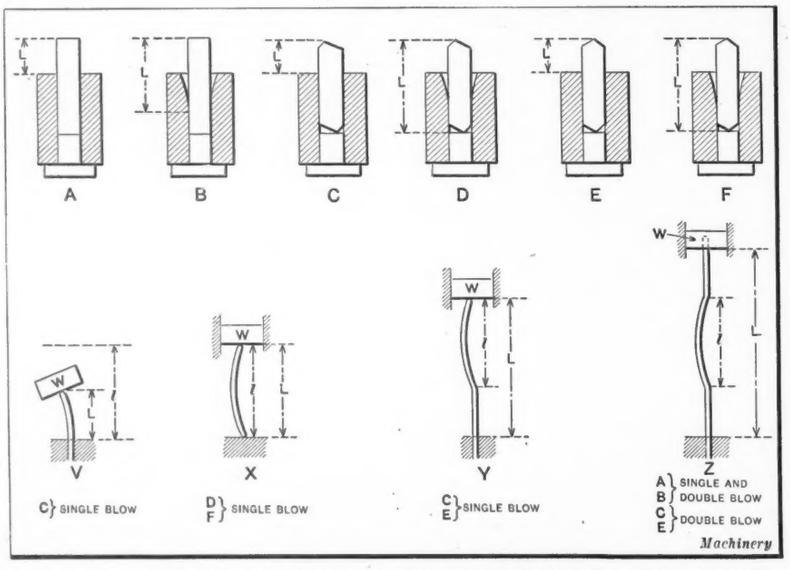


Fig. 3. Types of Cut-offs shown in Fig. 1 in Tight and Poorly Fitting Dies, and Comparative Lengths of Wire upset under Different Conditions

Severing the blank or cut-off from the wire is the first step in starting to make any part by the cold-heading process, and a consideration of the properties of this cut-off is the logical starting point in making a study of the conditions that exist in performing cold-heading operations. Referring to Fig. 1, *B* and *C* represent the two most common forms of cut-off used in automatic cold-headers; the form shown at *A* is a theoretical condition and could not be obtained in practice. When the load is perfectly central and the heading dies and machine are absolutely true, these three forms of cut-off, when struck by the upsetting machine, will tend to assume shapes similar to those shown in Fig. 2 at *D*, *E* and *F*, respectively. For all practical

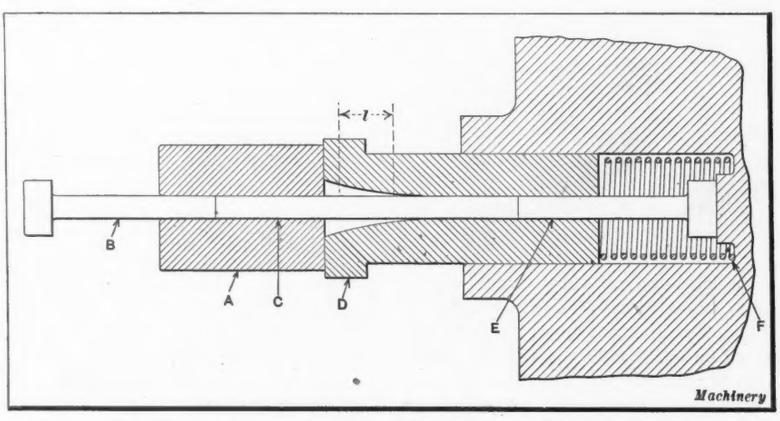


Fig. 4. Device sometimes used to obtain Larger Sized Heads by supporting Cut-off at Both Ends

[1] For other articles on this subject, see "Cold-heading," in the May and July, 1913, and the February, 1914, numbers of MACHINERY. MACHINERY'S Reference Book No. 119 contains the gist of these articles.

[2] Address: Kent, Ohio.

purposes, cut-off B can safely be assumed to approximate C, because the eccentricity of loading is not great, and roughness of the dies and softness of the wire will minimize the effect of eccentricity at the ends. It is well, however, to emphasize the evil that may result from this form of cut-off, as it may easily become serious if the dies fit poorly or become very dull.

At the top of Fig. 3 are shown the three types of cut-off illustrated in Fig. 1, each type being shown in a tight-fitting die and a worn die, respectively; at the bottom of the illustration are shown the comparative lengths of wire that can be upset for these different conditions. This illustration is developed from the theory of strains and stresses in struts presented in Goodman's "Mechanics Applied to Engineering." In these illustrations l designates what is known as the effective length of a strut, and in the present case is presented merely for illustrative purposes. At V is shown the condition for a single-blow machine and badly fitting dies, so that there would be no support for the projecting end of the wire when struck. The actual length of strut, *i. e.*, the length of wire which it is desired to upset, is shown at L, and in the case illustrated at V, $L = \frac{l}{2}$. For the condition shown at X, where both ends of the cut-off are guided in line but are free to pivot about the ends, $L = l$; in other words, the whole length of wire tends to bend, and with this type of loading it is only possible to handle rather a short length of wire, so that the amount of bending shall be as small as possible. At Y is shown the condition that exists when both the die and hammer fit well but when there is a tendency for the cut-off to pivot, due to the form of its ends. Here $L = 1.43 \times l$; in other words, it is well known that a strut thoroughly supported at one end will not bend through its entire length, but that a certain portion will be subjected to practically straight compression. When both ends of the blank are well fixed as shown at Z, the actual length that can be upset will be $L = 2 \times l$. To express this in another way, if an operator can produce on an ill-fitting, inaccurate header, satisfactory results that require as a maximum two diameters of wire for the head, he can with equal skill and less effort produce work requiring 2.86 diameters for the head if the operation is done on a well-fitting, accurate heading machine. Similarly, if he uses a well-fitting header and the nature of the work permits the wire to extend into and be supported by the hammer, four diameters of the wire can be headed without difficulty.

Fig. 3 shows the effect on the three forms of cut-off shown in Fig. 1, when the upsetting dies fit closely and when they have become a bad fit from excessive use or from some other cause. In this connection it should be explained that the actual length L that can be upset in an ill-fitting or bell-mouthed die will be the amount that projects beyond the point where the die fits the wire and not the amount of material that projects beyond the actual face of the die. Where this ill-fitting or bell-mouthing is not great, the initial upsetting of the wire will soon fill the additional space in the die, and little trouble will be experienced; but where there is a considerable bell-mouthing of the die, the maintenance of uniform heads on the work will be found very troublesome. It has been mentioned that the condition shown at A, Fig. 3, could not exist in practice, but if the cut-off could be made perfectly square so that it would fit into the cold-heading die without lost motion, a length of upset equal to that shown at Z could be obtained. In practice, the condition shown at B would be almost as good as that shown at A, in so far as the actual length of upset is concerned, but this length L now becomes the distance from the outer end of the blank to the point where this blank is actually supported by the die.

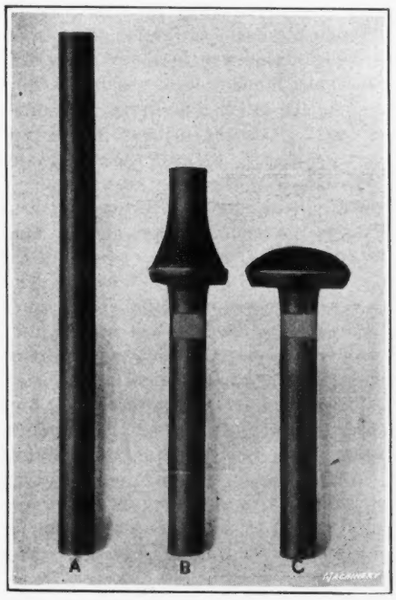


Fig. 5. Example of a Difficult Double-blow Job of Upsetting

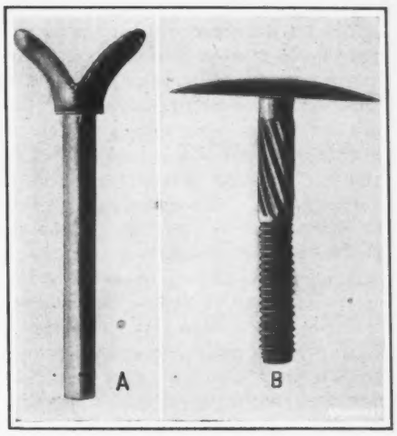


Fig. 6. Result of Four-blow Heading Operation; A shows Work after receiving Third Blow and B illustrates Piece as finished by Fourth Blow

At C is shown the most common form of cut-off. The comparative length L that can be upset at a single blow will vary from that shown at V to that shown at Y, depending upon the condition of the heading machine. At D is shown the same condition that is illustrated at C, except that the die is badly worn; and practically no head can be put on this blank and held uniformly central by a single blow. If the form of cut-off shown at C in Fig. 1 were substituted for that shown at B in any of the dies illustrated in Fig. 3, (see condition shown at E and F) somewhat better work would be obtained on account of the more central loading. In any case, absolutely uniform, centrally located heads can only be made by a single blow when the machines are in good repair and when the heads are made small enough to be formed from a short wire.

It is well known that the theory of struts—and more especially of short struts—is neither accurate nor complete. Therefore it is impossible to calculate exactly the length of wire that can be headed under various conditions to which reference has been made. However, the comparative amounts can be calculated, *i. e.*, the conditions shown in Fig. 3 are accurate under all conditions; but the actual amount L will vary even on the same header and with wire of the same chemical analysis, depending upon the physical treatment that the wire has received. By preparing the wire with especial care, and keeping all other conditions identical, it is possible to vary L within one or two diameters.

One frequently hears mention made of the so-called "2½ diameters" rule of thumb. This rule was evolved some years ago and will be found fairly accurate for work done on single-blow machines where the dies fit well and where the hammer is lined up with a fair degree of accuracy, but where the hammer affords no support for the work. The line along which operators work in attempting to produce articles that require more wire in the head than 2½ times the diameter, is shown at Z in Fig. 3, *i. e.*, where the hammer is accurately lined up and well supported, where the die fits the wire and where provision is made for the projecting end of the wire to be supported by the hammer. In extreme cases it is also necessary to have the wire straightened and especially drawn to overcome troubles incident to the unevenness of temper referred to in one of the preceding paragraphs. In Fig. 4 is shown the device sometimes used to further support the wire at both ends. In this illustration, A represents the die, B the knock-out pin, C the blank to be headed, and D the supporting hammer, which is advanced by spring pressure ahead of the main upsetting pin until it strikes the face of the die. It will be seen that a considerable amount of material may be upset in the cone by the action of upsetting pin E, while the unsupported or effective length of wire l is comparatively short. Spring F allows hammer D to telescope into the holder while heading pin E upsets the end of wire C.

The 2½ diameters rule of thumb for the amount that it is possible to upset at a single blow is only satisfactory for the general guidance of those who are inexperienced in work done on cold-heading machines. Greater lengths of wire are constantly being handled when proper care is taken in maintaining both machine and tools in satisfactory condition and by designing special tools to meet the requirements of unusual cases. The writer sees no reason why five diameters of wire should be the limit for the size of head that can be produced on a double-blow machine; as a matter of fact this amount is greatly exceeded under suitable conditions of operation. Fig. 5 shows an excellent example of difficult double-blow upsetting. At *A* is shown the blank before upsetting, at *B* the results obtained by the first blow and at *C* the finished piece after receiving the second blow. Owing to the fact that this piece requires a "swelled neck," a white band was painted around the work to indicate the real effective upset, which upon examination will be found to be nearly eight times the diameter of the wire. Although we find interesting and difficult work produced by double-blow heading operations, there is none that is more interesting or difficult than that which is done with the recently developed three- and four-blow headers. Fig. 6 shows one of the simpler of these operations where *A* represents the result of the third blow, and *B* the final result obtained by applying the fourth blow. There are numerous devices for accomplishing this purpose, all of which work on the principle of keeping the wire straight, centrally loaded and supported at both ends.

* * *

OUR MOST IMPORTANT INDUSTRY

BY J. P. BROPHY [1]

Did it ever occur to you that producing machine tools is a very ticklish though necessary business? This is true for many reasons. In the first place, the design must be well considered. If a blunder is made, the man who purchases a machine quickly discovers the fault and the manufacturer cannot escape severe criticism and loss of future business. Machine tools are purchased chiefly by companies that employ men whose judgment in such matters cannot be questioned. Genuine mechanics will not accept flimsy excuses, and therefore must be satisfied. If the tools should be sold to persons who know nothing about machinery, there is some chance to escape loss of business if the machinery is inferior in design or workmanship; but any person who expects to remain in the machine tool business must not attempt to market something that is not first-class. If he does, he will awaken to the fact that most men who are buying machine tools scrutinize them very closely before accepting them, and these men are as well qualified as the manufacturer to discover inferior design and workmanship. In the machine tool business, exceptional results are expected. Everything must be up to specifications and outputs must be maintained, as most purchasers crowd machine tools to the extreme. Unless the builder is very cautious, he will have a good deal of trouble.

Another reason why producing machine tools is a ticklish business is that machine tools are used in every town and city worth mentioning in this country, and if an inferior machine is sold in Boston, for instance, the man who might use such a tool in San Francisco learns that fact from various sources in a very short time. So extreme care must be taken in the building of these tools from the drawing-board to the shipping room. It may look easy to build planers and lathes to the man lacking experience; but anyone who tries will find that he has a tremendous job ahead. Duplications must be considered, and anyone who has not started at the bottom in some manufacturing plant on machine tool work and stayed with the business until it was a success can have no conception of what this undertaking is. Should the purchaser break some important piece, he will telegraph an order for that part and will expect prompt service. If he has to work a few hours placing this piece in position, he will send the manufacturer a bill for his labor.

[1] Vice-president and general manager, Cleveland Automatic Machine Co., Cleveland, Ohio.

Such exactness is not demanded of other kinds of machines. Those who build engines, pumps, printing presses, motors and many other kinds of machines that are well made and designed are given an opportunity to correct any fault that may develop, but should the milling machine or lathe, screw machine, planer, gear-cutter, grinder, boring mill, etc., look out of proportion, that is, appear too heavy or too light, or if it has not a good appearance, seems too complicated, etc., there will be condemnation from some source. In addition, if a machine will not stand the test as a producer, using high-speed cutting tools, this fact will soon be known, for competent men will test it in all sections of this country.

This is the age of real efficiency, a real hurry-up age; time is the all-important factor and a minute is divided into many parts. In making estimates on production to meet competition, it is necessary to take advantage of all possible time-saving devices, and in this field the machine tool leads the way. The American tool builder has been the pioneer in developing devices that lower the cost, and he is expected to continue the good work. He must keep on improving. In every line of work in which metal is employed, the machine tool is likely to be necessary in producing the first model, and when the business is exploited the machine tool is a most essential element in its success. The fine results obtained, in many instances, through the guaranteed outputs of machine tools is the only hope of the inventor and his associates in keeping down the cost of production, who thus add another line of business and keep workmen busy.

Machine tools, without question, are of more importance than any other line of machines; they are the real foundation of many industries and much is expected of them. In any country, the manufacture of the ordinary things, including the locomotive and the powerful engines of an ocean liner, would not be possible without machine tools; so if a tool manufacturer is careless in designing his machines, allowing himself to think that this or that is good enough, when he knows better, he will soon agree that the first statement of this article is true.

The adaptability of machine tools of all kinds to work where duplication is necessary, completing a piece in one operation or adding special features in many operations, often makes the cost of the article so low as to seem almost unbelievable. As a result, the capitalist is encouraged to invest freely, for he knows that all those engaged in the machine tool business can be consulted as to the probable cost of producing almost any shape from the bar, and in many instances from castings, and that these men can always guarantee results. This is conclusive proof that the business is ticklish, although necessary, and that exaggerations in making estimates, coupled with faulty design, must be avoided. Any manufacturer who requires special machines in his business cannot possibly consider such work until he is equipped with the various kinds of machine tools that form the foundation of nearly all things mechanical. The lathe, planer, milling machine, gear-cutter, etc., are all important tools, while the grinder, boring mill, screw machine, keyseater, etc., are, without question, essential in the production of accurate work at low cost.

The writer hopes that this article will prove that this country owes a vote of thanks to the men who have done so much toward building up the great manufacturing interests of this nation, until we are superior to all others, and who have helped to a wonderful extent in encouraging the mechanical brains of our country, knowing the machine tool manufacturer will find the way to produce the article they have in mind. Everlastingly at it is characteristic of all leading men engaged in the machine tool business; they are always improving their product to enable the user to lower his cost and consequently enlarge his own business. As a result, all civilized nations have studied our tool designs closely and have copied nearly every machine of merit produced in America. So the credit of actually uplifting our own and all other countries mechanically should be given to the men who never cease to improve the tools that rapidly produce millions of different shaped metal pieces with accuracy and at the minimum cost. This conclusively proves the business in question to be a very necessary one.

DIAMONDS FOR DRESSING GRINDING WHEELS

FACTORS GOVERNING THE VALUE OF BORT DIAMONDS AND METHODS OF SETTING AND USING THEM

BY G. T. LINTING [1]

DIAMONDS commonly used for dressing grinding wheels are called bort diamonds. They come from the same source as our gems and comprise a large percentage of the diamond-mine product. Primarily, diamonds are mined for the gem-quality stones only and bort is the refuse; it consists of all stones not good enough for gems on account of being cracked, off-color, impregnated with foreign matter, etc., but which can be used as tools. Other refuse consists of stones of such poor quality that they can be used only for crushing into diamond dust; this dust is used for cutting gem diamonds.

The hardest and best quality diamonds formerly came from India, but as that country has ceased to produce any appreciable quantity, we receive no bort from that source. Brazil is also a producer of very hard and fine quality stones, which are principally found in river gravel or a matrix of such where they have lain for ages, which accounts for their polished appearance. Brazilian bort diamonds are the most desirable on account of their hardness and comparative freedom from cracks and other flaws commonly found in the African stone. They can be easily distinguished by their polished appearance and their almost invariable apple-green yellow color. They are also much higher in price than the African product. The amount of the Brazilian product, however, has been decreasing of late years.

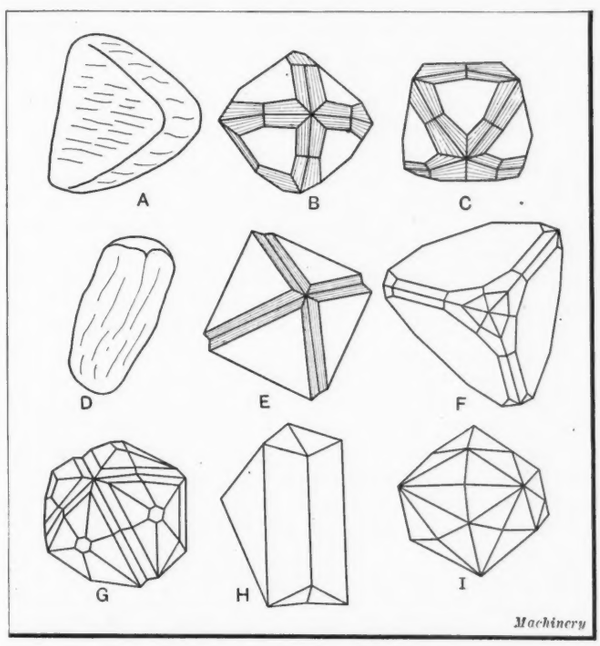


Fig. 1. Common Shapes of Wheel-dressing Diamonds

Over 90 per cent of the diamonds produced today come from the South African mines. The product of these mines is controlled by a selling syndicate in London, which fixes the price and limits production to just what the market will absorb. This accounts, in part, for the rapid rise in prices of all stones. This situation peculiarly affects the market for bort for the following reason: The world demand for diamonds has fallen to a very low ebb on account of the war—the United States being the only good customer. As a result, there is a restricted output of the mines, which are operated for the gem diamond alone, and the quantity of bort produced corresponds with the reduced supply of gem stones. The small supply of bort, coupled with the increased demand on account of the greatly increased industrial activity of the last two years, also accounts for the rapid rise in price, and it is predicted by the diamond-trade journals that the price will go much higher in the near future. Until two years ago, the price of wheel-dressing diamonds ranged from about $8 per carat, for poor-quality goods, to $15 per carat for the best grade. The price has now advanced from 200 to 400 per cent, and the quality and quantity has steadily decreased, until it behooves the manufacturer to look well to his supply and select his stock with great care. The enormous demand and the small available supply of these stones has resulted in much trash being put on the market, which is frequently mixed with better grade goods. It is almost impossible for the average purchaser, even with a magnifying glass, to grade the stones intelligently. Therefore, it would seem economical for the large purchasers to employ an expert to examine each and every stone and reject such as are unsuitable.

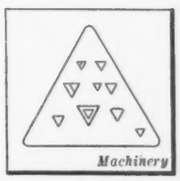


Fig. 2. Triangular Depressions in Sides of Diamonds

Selecting the Diamonds

The shape of a wheel-dressing diamond is an important factor in determining its value; the ideal shape is a perfect octahedron, or an eight-sided crystal. Such a stone has six hard points, which can be seen with the naked eye. As each point may in turn be presented to the wheel, this stone will render the greatest amount of service, other qualities being equal. It can also be held in the holder more easily than any other form. The next best shapes are the various modifications of the octahedron, which are shown at *B*, *C*, *E*, *G* and *I*, Fig. 1. These will vary from the stone with five good points and one blunt point to an irregular sphere. The less marked the points, the more difficult it is for the setter to determine the proper setting and the greater is the liability of setting a side instead of a point to the wheel. Such a setting will result in rapid wear on account of cutting with the lines of cleavage, or grain, instead of against them.

The form shown at *G* is known as a hexakisoctahedron, or an octahedron with a six-sided formation upon each of the eight sides. This form can be readily distinguished by the appearance of the six scalene triangles upon each side. As this stone is almost round in shape, it will render less service per carat than the regular octahedron, but it is a very good shape. A shape occasionally found, shown at *F*, is a triangular, cone-shaped stone with four hard points. It is compact in shape and is of good form, except that it has only four hard points, while the octahedron has six. It is therefore worth less, per carat, than the more perfectly shaped stone.

Other common shapes are modifications of the octahedron that have one or more additional hard points in close proximity to a natural point; such a stone is shown at *H*. These are called macles, or twins. Such shapes are less valuable than the preceding on account of the difficulty in determining the cleavage lines or the proper point to present to the wheel, and the consequent grinding away of the adjacent points. It is impossible to set a stone of this kind without presenting some of the cleavage lines sidewise to the wheel. All of the foregoing shapes are called close goods on account of their compactness.

Next come the flat triangular shaped stones *A*. As these have

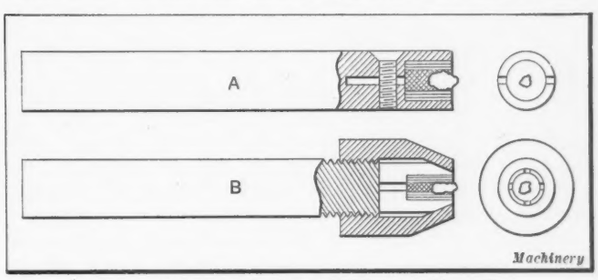


Fig. 3. Methods of holding Wheel-dressing Diamonds

[1]Address: Chief tool designer, Nordyke & Marmon Co., Indianapolis, Ind.

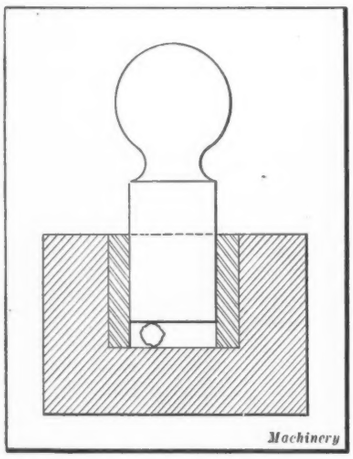


Fig. 4. Mortar for pulverizing Diamonds

but three hard points, they will not render the service of a stone with more points. These are not bad stones, however, if the points are stubby and the cleavage lines can be determined. The least desirable is a long, slender stone *D* that has been broken from a larger crystal. Such a stone must be set with reference to its mechanical shape, and its cleavage lines and hard points ignored. It will wear away much faster, is more likely to break, and can be reset fewer times than the octahedrons. Such stones are worth about one-half as much as the more compact shapes.

As shown at *B*, *C* and *E*, striations occasionally appear upon the corners and edges of the diamonds. These stria are excellent guides in determining the cleavage lines, and the more marked they are, the easier it is for the setter to recognize the natural hard points, and thus determine the proper setting. Other valuable aids in determining which are the natural hard points are the small triangular depressions that frequently appear on the sides of the diamond, as shown in Fig. 2. The natural hard points are always perpendicular to the base of these triangles, which are readily recognized. These depressions occur in almost half the stones on the market. They appear upon the sides of the stones even after the sides have been flaked off, proving the cleavage lines and indicating that the crystal is built up of a series of layers.

Color of Stones

Another important consideration in the selecting of a stone is its color. The hardest and therefore the best stones are of a clear white crystal or grayish color; in fact, the less color the more valuable is the stone. The colors run from white through varying shades of blue, green, yellow, and brown to black. The various shades of brown indicate the presence of iron oxide and depreciate the value of the stone. In fact, color of any kind indicates the presence of impurities, and therefore softness. The apple-green color, blending into a canary yellow, of the Brazilian bort is an exception, however. One should not be misled by a superficial examination of an apparently brown stone, however, for under the magnifying glass the body of the stone may show a quite clear crystalline structure and the color may be merely superficial—on the surface only. Such a color does not detract from the value of the diamond, but the deep brown stone, with or without visible cracks, is of the poorest quality. Diamonds from the Wesselton South African mines occasionally have this greenish-yellow color and may be mistaken, by the uninformed, for true Brazilians.

Cracks and Flaws

Cracks or flaws come in all bort diamonds; if it were not for cracks and other flaws they would be classed as gems. It is necessary to examine a stone very carefully in order to discover all the cracks, as they are frequently difficult to see. Cracks are more or less serious, according to their location and the direction of cleavage. If one should appear directly under and at right angles to a hard point, it is probable that such a point will break off almost immediately, and that part of the stone will be lost; also, the diamond will require resetting. Should a crack appear parallel to the axis of a hard point, the stone should be used so that the crack will be in a perpendicular plane, in which position it will probably do little harm.

Frequently one or more of the hard points of the stone will have the appearance of frozen snow or show a honeycomb appearance. Such a point is very poor and will wear away rapidly. Interior black spots and bubbles are a serious defect and affect the value according to their size, number and location.

Setting and Using Diamonds

It is very important that the setting be properly done; otherwise much of the care employed in the selection of good stones will be wasted. Frequently a stone that is poorly set will fall out and be lost. If the proper point is not set outward, the full value of the diamond is not realized on account of rapid wear. The setter should be instructed to examine each stone carefully before setting to determine the natural hard points and set the stone accordingly. It can readily be seen that any stone will wear more rapidly if it is so set that the wear will be parallel with the lines of cleavage, or grain, instead of at right angles to these lines.

There are various methods of setting bort diamonds. An excellent way is to cast the diamond in solid steel; another good way is to wrap it with strip sheet copper, about 1/16 inch thick by 3/4 inch wide, until the cylinder is about 1/2 inch in diameter; then pour hard solder around the stone and place the cylinder in a holder, as at *A*, Fig. 3. At *B* is shown a similar holder, but the copper cylinder is held in place by a collet instead of being clamped by a screw. These holders have an advantage over those that are cast solid because the copper cylinder can be easily removed from the holder, the diamond reset, wrapped, resoldered and then replaced in the holder.

Too much care cannot be used by the operator in dressing the wheel, for while the diamond is the hardest substance known, it is very brittle. For this reason, should the operator jam the diamond into the wheel, he may break the stone. The brittleness of the diamond is shown by the method used to produce diamond dust. A diamond is placed in a mortar, Fig. 4, that has been liberally oiled and the pestle is struck sharp blows with a hammer until diamond dust of the required fineness is produced. If the operator of the grinding machine is taught the brittleness of these stones, he will be more careful of them.

The diamond holder, which should accompany the grinding machine, should be so constructed that the diamond will be presented to the wheel at right angles, or slightly below a right angle, to the periphery of the wheel. Finally, each diamond should be numbered and weighed and a record kept of the number of times it is reset and of the service rendered; thus the purchaser can keep an intelligent record of its performance.

Summary

Have all diamonds selected by one who is competent to judge the relative value of the stones. See that they are properly set and reset and that the operator is fully instructed as to the nature of the diamond and a proper method of presenting it to the wheel. Keep an accurate record of the service rendered by each stone. If these instructions are properly carried out, they should result in a marked saving to users of diamonds for dressing grinding wheels.

* * *

Every enlisted man and officer of the navy, in accordance with a regulation issued by Secretary Daniels, is to wear an indestructible metal tag by which he may be identified in the event of death or injury. The tag is to be made of monel, an alloy which is not affected by heat and which will not corrode in salt water. It will bear on one side the wearer's name, date of birth and enlistment, and in the case of an officer, his rank and date of appointment. On the other side will be etched the print of the right index finger. Under this system, finger-print experts estimate that there is not one chance in 65,000,000 of a mistake in identification. The finger print is taken in ink on the metal, the name and dates are written on the tag, and the latter is sprinkled with powdered asphaltum and held over an alcohol lamp until the asphaltum melts into the ink. The tag is then placed in a nitric acid bath, which etches the finger print and inscription on the metal.

* * *

This country is now turning nearly 1,000,000 bales of cotton into explosives each year.

ELECTRIC JAPANNING[1]

The term japanning refers principally to the covering of wood or metal with a coat of black varnish and hardening by baking in an oven. The process can be regarded as a step between painting and porcelain enameling. Records show that as early as 392 B.C. the Japanese applied to wood the juice of a tree, known as Rhus-vernicefera, belonging to the same family as the sumach. As the liquid oxidized, it turned black and formed a glossy, smooth lacquer. The product was costly and the process took considerable time, but the finished articles withstood the elements for years.

When the work was taken up in Europe in about the fifteenth century, a substitute for the Japanese lacquer was found; this consisted essentially of the same constituents as our present-day japan, usually an asphaltum base combined with oils, dryers and various oxides. The solvents keep the material liquid until it has spread or flowed evenly over the surface to be coated, whereupon it evaporates, leaving a smooth, viscous covering. The material thus left is changed from a viscous to an elastic solid by oxidation, the action being quickened by raising the temperature.

Great strides have been made in shortening the time of japanning operations in the last few years. Work that formerly required from five to nine hours is now done in from thirty minutes to one hour, and even better speeds are expected, especially with the electric oven. The heating units of this oven consist, in general, of a framework of steel or cast iron, supporting insulators made from mineral compounds which afford high insulation resistance even at the fusing point of the metal resistor. This resistor is usually a nickel-chrome alloy, manufactured as a flat ribbon, which is wound continuously around two insulators, thus forming one heating unit. It is non-corrosive in air at 800 degrees C., but in japanning ovens the air seldom reaches a temperature above 600 degrees F. Practice has shown that it is best, where a number of these heaters are connected, as in ovens, to use steel bus bars and to have all connections mounted on insulators having the same characteristics as the heat insulators. The complete heater usually runs in units of from 2½ to 10 kilowatts, which may be placed anywhere on the walls or floor of an oven until practically a uniform temperature is obtained throughout. This leads to high quality finish and speed together with duplication of work, both as to quality and time. Microphotographs taken of japanned pieces, where the same grade of metal was covered by the same japan in the same room, one man performing all operations, show that the higher the proportion of heat by radiation and the less by convection, the higher is the quality of the work. The second coat baked electrically is superior to a third coat of the other type.

The control of temperatures in japanning is most essential, especially where it is desired to insure uniform production of duplicate parts. Electric control is of two kinds, hand and automatic. Hand control consists of numerous switches so connected with the heating elements that the desired number of heaters to produce or hold a given temperature can readily be turned on or off. This is a cut-and-try method, but in several instances is giving satisfactory service. Automatic control consists of a capillary-tube thermometer that actuates a contactor through a relay, throwing off part or all of the heaters when the oven reaches the desired temperature, and again throwing in these heaters when the temperature falls. The bulb, or sensitive member, of the thermometer is usually about 15 feet in length and is immersed inside the oven. The extension of this tube outside the oven is armored and made of sufficient length to locate the instrument properly. A liquid that vaporizes at a temperature slightly above ordinary atmospheric temperature is used as the actuating fluid. The instrument has two indicator hands, which are set at the maximum and minimum points of temperature desired.

Heat Losses and Ventilation

The principal heat losses of a japan oven are losses due to radiation from the oven, losses due to ventilation, and losses due to absorption of heat by the work together with all parts within the oven. The less the radiation and ventilation losses from the oven, the greater is the amount of heat available for actual work. As a result, the oven walls, roof, and floor should be constructed of a high-grade heat-insulating material and should have little mass, in order to keep its heat absorption as low as possible. A 4-inch to 6-inch wall lined with diatomic earth or similar products seems to meet these requirements. Furthermore, as little through metal as possible should run from the inside to the outside of the oven. The thermal conductivity value of wrought iron and mild steel, such as is used for channel irons and bolts, is about 1400 times that of a good insulating material; a ¼-inch bolt will radiate nearly the same amount of heat to the outside air as a 7-inch square of good insulating material.

From both a baking and a safety standpoint, just enough air must be brought into the oven to reduce the vapors given off by the japan to below a point where it becomes an explosive mixture; but not enough air should be brought in to cool the oven and retard the baking. This means that for every gallon of japan baked within an oven at one time, 1200 cubic feet of free air should be taken into the oven during the vaporizing period. It has also been found good practice to have the ventilators distributed in different parts of the oven. As the volatiles liberated from the japan are heavier than air, it is well to place some of these ventilator openings where the heavy gases will be removed first. With radiation, ventilation, and absorption values expressed in British thermal units, the installation of the proper number of electric heaters to equalize these losses becomes a simple matter. For, when heat is generated electrically, its conversion is accompanied by 100 per cent efficiency; in other words, one kilowatt-hour will always generate 3412 British thermal units.

Types of Japanning Ovens

Japanning ovens can be divided into three types: the box or kiln type, the semi-continuous conveyor type, and the continuous conveyor type. Little need be said about the box type, as everyone is more or less familiar with its construction. As used electrically the heaters are arranged on the side to give the proper distribution of heat. The semi-continuous conveyor oven has become popular with manufacturers who do not have sufficient output of one kind to warrant carrying on the operation continuously. It may be a rotary oven or a box type oven with a conveyor that is moved as the operator desires. The rotary oven is built in the form of a cylinder with a heat-insulating partition through the center; with this arrangement, the operator can load half the oven while the other half is baking. This oven is convenient when many pieces of different sizes and shapes are to be japanned. In the conveyor box type oven, doors are placed at both ends and a conveyor runs through the upper part, from which the work is hung. This conveyor is made long enough to extend the same distance beyond each end of the oven as its length within. One charge is baking within this oven while another charge is being loaded on the receiving end. When the first japan coat is baked, the conveyor takes the baked pieces out of the discharging end and the newly dipped pieces into the baking chamber. Ovens of this type are usually built double or triple, depending on whether two- or three-coat work is desired.

The continuous conveyor oven is much more efficient than the others. It consists usually of a long enclosure through which the work is passed on a slowly moving conveying apparatus. If desired, all handling may be eliminated by installing apparatus for loading and unloading the conveyor automatically. In most cases, the electric heaters are so arranged within the different sections of the enclosure that the incoming work is brought up to its final baking temperature by steps. Usually no heaters are installed in the first section of the enclosure, as the hot baked work is brought out of the oven in such a way as to give up a good share of its stored up heat to the cold incoming work. For the same amount of energy consumed, as much as three times the amount of work has been gotten out of the conveyor oven as out of the box type.

[1]Abstract of a paper read before the Cleveland Engineering Society, April, 1917, by C. D. Carlson, Engineer, Cleveland Electric Illuminating Co., Cleveland, Ohio.

Fire Risk with Electric Ovens

Electrically heated ovens, from the first, have been looked upon as the solution of the problem of preventing the fires and explosions that were so common in japanning. Yet even in electric ovens two kinds of fires are possible, although at the same time easily preventable if proper care is taken to clean the ovens thoroughly and regularly. When pieces freshly dipped with japan are placed within an oven, there is likely to be what is called a secondary drip when the heat is first applied. This waste japan bakes on the floor of the oven and each successive oven charge adds to the accumulation until a thick, porous crust of baked japan has formed, which, when heated from 500 to 600 degrees F. in the presence of oxygen, will ignite spontaneously. If confined to the oven floor, this burning is harmless, but if it reaches freshly japanned work, a disastrous fire may result.

Again, when the volatiles given off by the japan strike a surface with a temperature lower than their own, they condense; naturally the flues of the oven will gather most of this condensed volatile. These deposits may ignite spontaneously, backfiring into the oven, or the flues may become so clogged with them that proper ventilation is cut off, leaving an explosive mixture within the oven. Then ignition of any sort might cause serious results. From an electrical standpoint great care has been taken to prevent ignition, even where the precautionary measures have been disregarded, as the heating units are designed to have a temperature not much over 100 degrees F. in excess of the oven baking temperatures. Except in unusual cases, this temperature is below the flashing point of japans.

Results of Electric Japanning

Electric japanning is a new industry, having practically grown up within the past three years. Among its largest users are automobile builders, one of whom is baking its cars almost entirely by electric heat. The success of electric heat in japan and varnish oven work has led to considerable investigation along the line of what might be called low-temperature heating; that is, temperatures up to 600 degrees F. The results of these investigations have disclosed numerous other applications, most prominent among which are electric core-baking ovens, electric bread-baking ovens, ovens for baking cereals, drying woolen articles, and equipments for sherardizing. The applications of industrial electric heating are being developed along sound engineering lines, and thus have brought out quality, accurateness, speed, and efficiency, all of which tend to a firm commercial development.

* * *

CASTING OF GERMAN SILVER[1]

German silver is a composition of nickel, copper and zinc in varying proportions. Its value in the arts depends on its color, luster, hardness, tenacity, toughness, malleability, ductility, machining qualities, and resistance to alkalies and acids. Generally speaking, it is manufactured in three ways. The German method is to melt all the copper and two-thirds of the nickel and zinc in a graphite crucible and then add the rest of the nickel and zinc. In the English method, all the copper, nickel and zinc are melted at one time, then zinc and copper are added; should a test show that the metal is porous, a fireclay pipe containing pitch is pushed into the metal to deoxidize it. One American method is to melt a copper-nickel alloy and then gradually add the preheated zinc. In another method, monel metal is used as a base, the necessary copper and zinc being added later.

One of the great difficulties found in the preparation of German silver is to so unite its constituents as to avoid porosity and produce a homogeneous alloy. Besides having a high melting temperature, nickel has an affinity for carbon and nitrogen at a high temperature and occludes both hydrogen and nitrogen within its pores. A good protection against these ills is to prevent the access of these gases to the metal by a protective covering and a deoxidizing flux. Charcoal should not be used alone as a covering; broken glass and a small amount of soda ash or calcined borax are much better. A good deoxidizing flux is the proper use of zinc in the making of the alloy; also, the careful stirring through the hot mass of a small amount of dry chloride of zinc just after skimming the pot preparatory to pouring.

Very good quality castings have been secured by adding 4 ounces of cupro-nickel-vanadium to the molten bath, just about five minutes before the heat is ready to pour. The cupro-nickel-vanadium, either in granulated form or broken into small pieces, is wrapped in a piece of paper so as to keep the mass together. After it becomes a bright cherry red, it is pushed down and held near the bottom with an inverted cupped disk having a handle about 4 feet long. When the mass is completely absorbed by the charge, the metal is gently stirred with a pumping motion and then allowed to remain quiet for about five minutes, so as to give the vanadium a chance to perform its scouring and purifying action. When the metal reaches a clear, limpid state, as evidenced by its greater mobility, the heat is ready to pour.

Any alloy containing nickel chills with surprising rapidity and thickens by rapid oxidation; moreover, its shrinkage, when reaching the freezing point, is great. To overcome its tendency to chill, the melting point must be materially reduced by the use of some alloy that will promote its fluidity. The introduction of a little aluminum-zinc alloy is advisable when the castings do not have to sustain a hydraulic test; otherwise a calcium-zinc alloy may be used. To overcome the tendency to rapid oxidation on the surface of the bath, chloride of zinc in a perfectly dry state is almost a specific. To overcome excessive shrinkage, the runner must have sufficient thickness.

While chloride of zinc will preserve the metal from surface oxidation, it will not protect the body of the molten charge from absorbing such gases as oxygen, nitrogen and sulphur. The only reagent that will reach these products is one that will be decomposed by them when in a nascent state so as to act as a carrier for them and bring them to the surface to be absorbed in the slag, or some element that has a greater affinity for them than the basic metal in the pot, such as zirconium, boron and titanium. Vanadium acts as a carrier of oxygen and has a strong affinity for nitrogen and sulphur, so that it is the most rapid and thorough reagent. But a pure product of cupro-vanadium must be used; one having any aluminum at all should not be used for castings requiring a severe hydraulic test.

Having secured a perfect composition and skillful treatment at the melter's hands, the foundryman is still far from ultimate success. The body of his mold must be an open sand and his facing must be of some fine molding sand, which must be skin dried and then the molds must be smoked by a torch. When a heavy casting is to be made, even these precautions will not insure success. The sprue head and main feed gate must be brushed down with graphite and smoothed down with a slicking tool; the mold must be vented at all places where it is possible for the gas to become trapped or pocketed; the core must be well made and vented, if necessary; and the metal must be properly skimmed before pouring, and then poured with a uniformly steady stream, at such a rate as to keep the descending column full, so as to avoid spelter marks and cold-shuts. The art of making sound German silver castings is one that is accompanied by infinite precautions, painstaking details and absolute thoroughness.

* * *

The scarcity of coal in the neutral countries in Europe during the past two years has made it necessary for these countries to investigate all the possibilities of finding coal within their own borders. Last summer drillings were made in Iceland, by means of which it was determined that in one place there are at least 180,000,000 tons of coal available. This coal is of high quality, and as a result of the investigations, a Danish company has been formed for mining the coal. In Sweden a company has been formed for mining coal in Spitzbergen, and drillings are also to be made in the southern part of Sweden, where it is expected that coal will be found at a considerable depth.

[1]Abstract of a paper read before the American Institute of Metals by C. P. Karr.

MARINE ENGINE CONSTRUCTION

METHODS USED IN BOSTON NAVY YARD FOR MAKING ENGINES OF NEW SUPPLY SHIP "HORATIO BRIDGE"

BY N. I. MOSHER [1]

THE supply ship *Horatio Bridge* was the first large steel ship ever constructed at the Boston Navy Yard. The propelling machinery, which consisted of two sets of vertical inverted-cylinder, direct-acting, three-cylinder, triple-expansion engines, with the necessary auxiliaries, was made in the shops of the machinery division. This work was carried on between the repair periods of naval fleets, thus tending to hold together a permanent organization of skilled mechanics, and to this end proved very satisfactory.

Fig. 1 shows one section of the bedplate secured to the planer platen. In this position the bottom and both ends are being planed at once, four tools being in operation. After the bottom and ends of each section are planed, the sections are drilled and bolted together. Fig. 2 shows the three sections of the bedplate bolted together and mounted on an open-side planer while the column seats and bearing housings are being planed. Performing these two operations at one setting insures perfect alignment. Fig. 3 shows the operation of boring bolt holes for securing the bearings and caps to the housings, the radial drill being mounted on the bedplate. A portable crane mounted on the opposite end of the bedplate handles the bearing boxes while they are being fitted to the housings. By this method much time was saved, owing to the large overhead crane not being available at all times. The weight of the bedplate with its bearings is approximately 25 tons. Fig. 4 shows the twelve main bearing caps being planed at one setting, while Fig. 7 shows a bearing and cap fitted into a fixture for boring and squaring up the ends. Fig. 8 shows 120 main bearing shims of various thicknesses pressed together and

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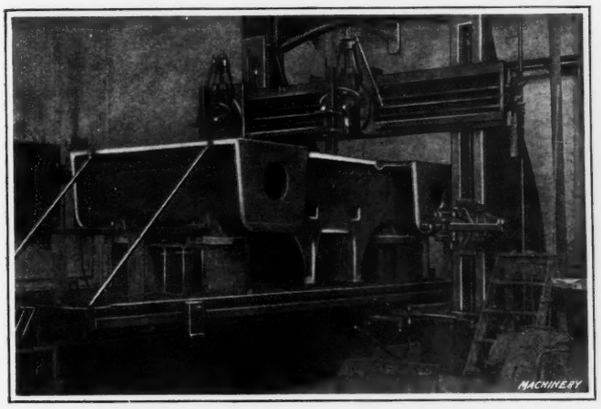

Fig. 1. One Section of Bedplate set up on Planer to enable Bottom and Both Ends to be planed simultaneously

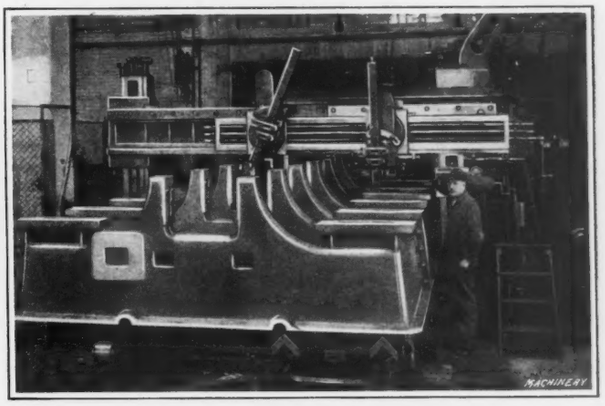

Fig. 2. Three Sections of Bedplate bolted together and set up on Planer for finishing Column Seats and Bearing Housings

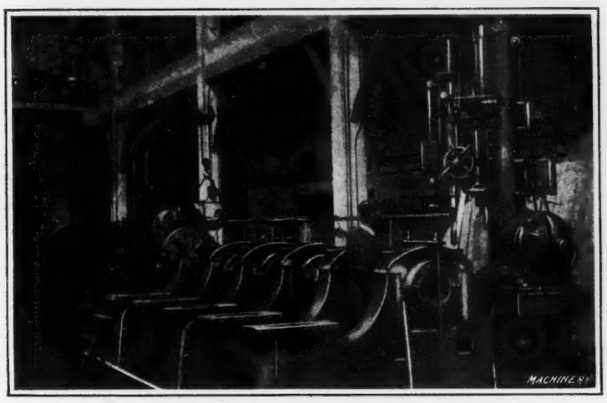

Fig. 3. Boring Bolt Holes for securing Bearings and Bearing Caps to Housings. Radial Drill is mounted on Bedplate

Fig. 4. Twelve Main Bearing Caps set up to be planed at a Single Operation, thus saving a Considerable Amount of Time

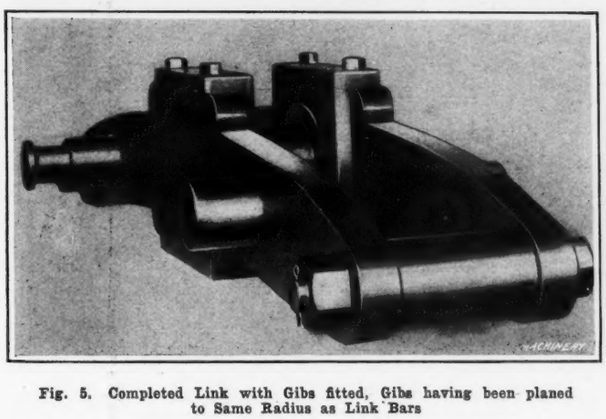

Fig. 5. Completed Link with Gibs fitted, Gibs having been planed to Same Radius as Link Bars

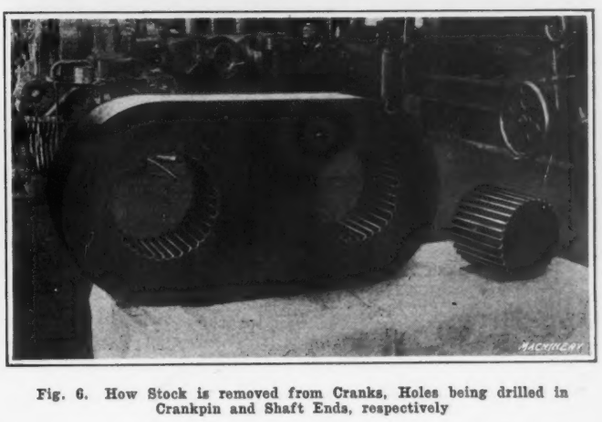

Fig. 6. How Stock is removed from Cranks, Holes being drilled in Crankpin and Shaft Ends, respectively

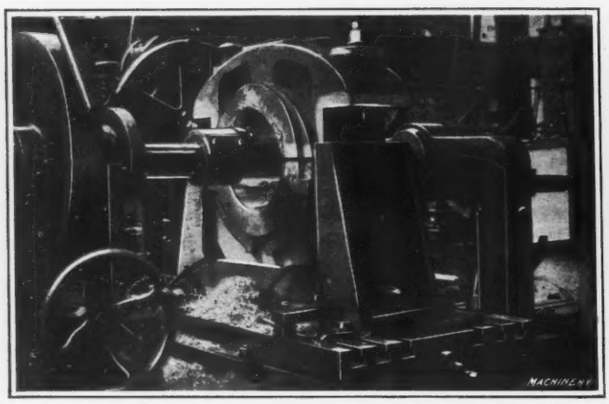

Fig. 7. Bearing and Cap mounted in Fixtures for boring Bearing and squaring up Ends at a Single Setting

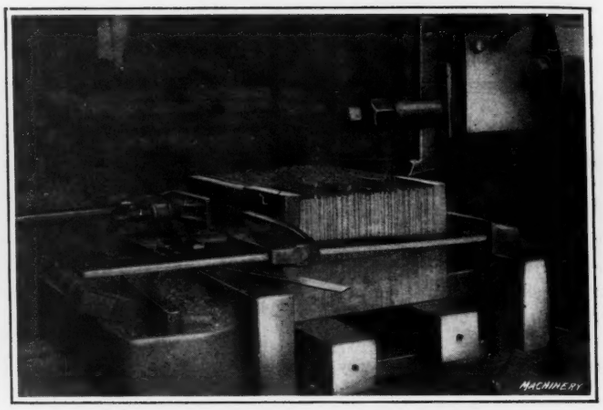

Fig. 8. How 120 Main Bearing Shims of Various Thicknesses are pressed together as Solid Block and planed to Desired Shape

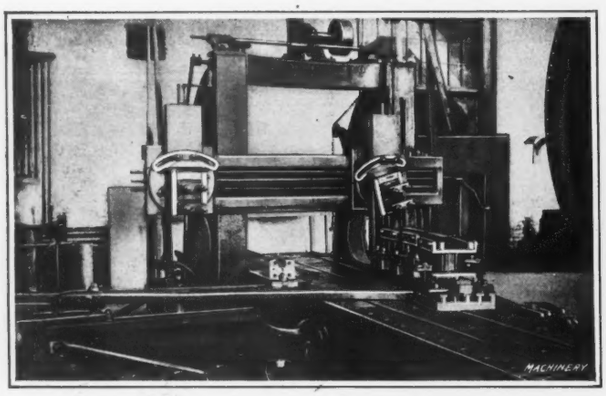

Fig. 9. How Engine Link Blocks are planed in Pairs on Radius Planer Attachment, which insures Accuracy of Work

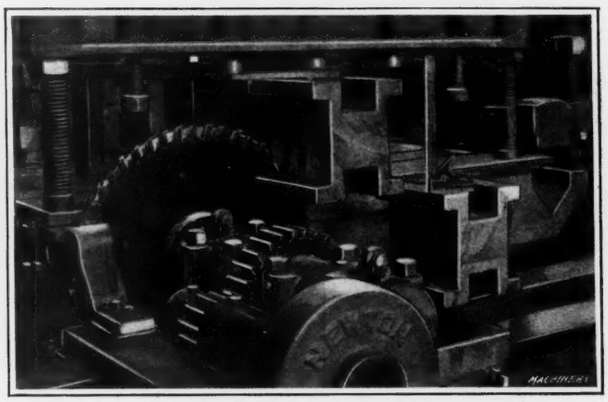

Fig. 10. Link Blocks being cut from Billet on Newton Cold Saw. Billet has been planed to Desired Cross-section

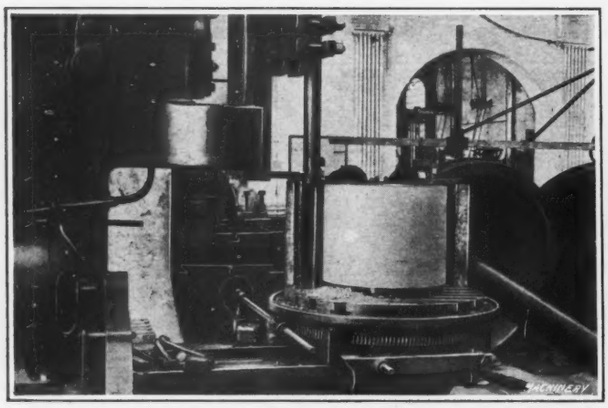

Fig. 11. Crank Webs set up in Pairs on Slotter Platen for rounding Ends and cutting Keyways

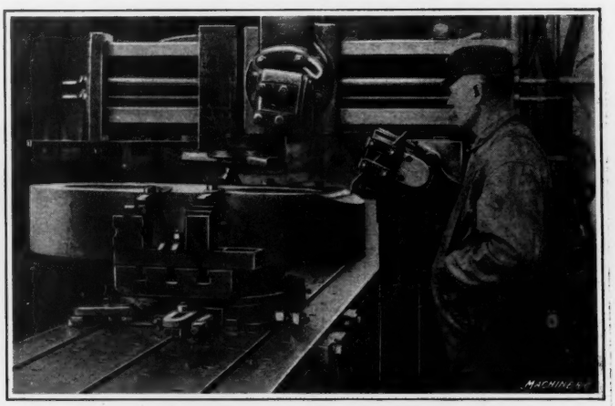

Fig. 12. Crankshaft Web mounted on Radius Planing Attachment for cutting Clearance at Top of Web

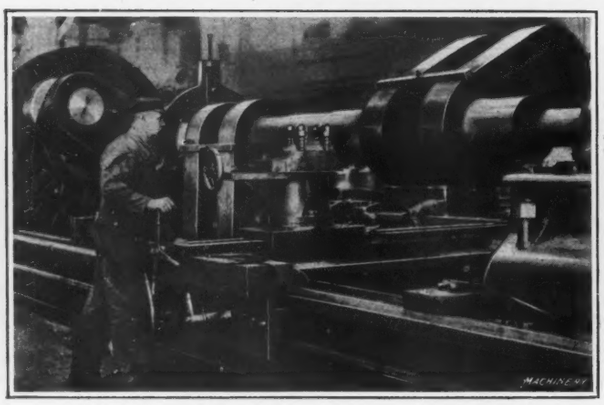

Fig. 13. Crankshaft assembled and set up on Lathe ready for finish-turning Journals and Eccentric Seats

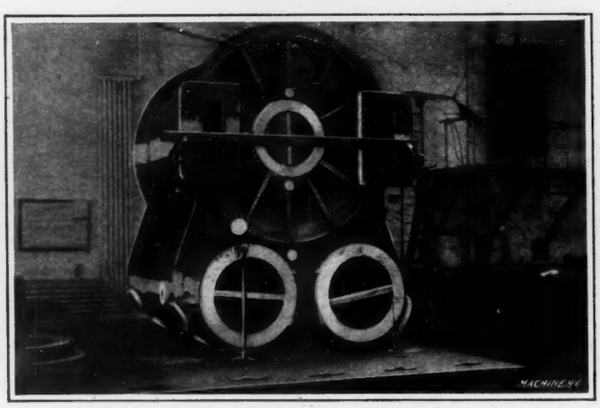

Fig. 14. Low-pressure Cylinder on Lay-out Platen ready for Inspection and Establishment of Centers and Finish Lines

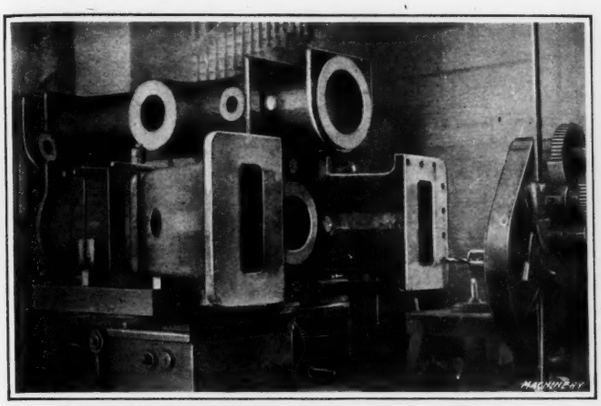

Fig. 15. High-pressure Cylinder mounted on Horizontal Mill for Boring, Milling and Drilling Operations

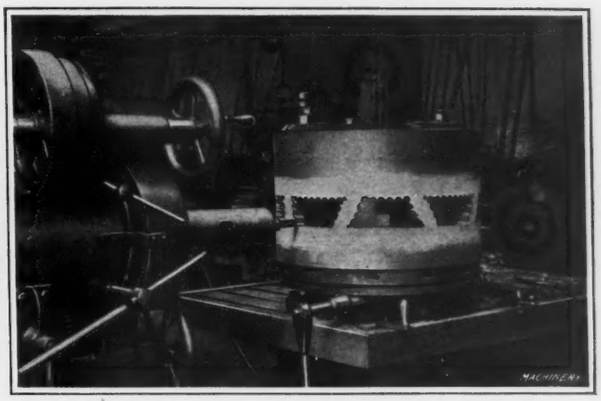

Fig. 16. Cutting out Ports of Valve Cages from Solid Metal, which gives Clean Castings and Sharp Port Edges

Fig. 17. Babbitting Department equipped with Oil-burning Forge, Iron Bench and One-half Ton Jib Crane

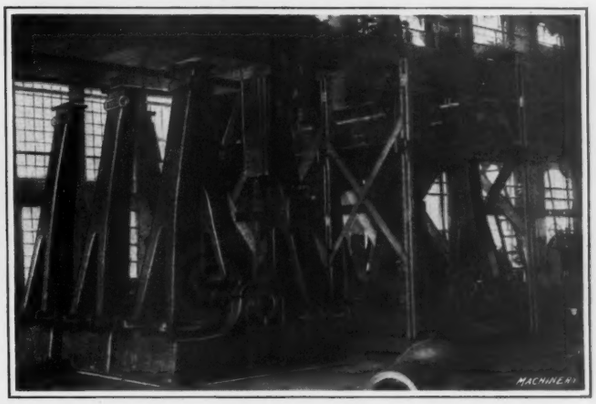

Fig. 18. Starting Erection of Engine in Shop. Three Sections of Bedplate are bolted together and Columns erected

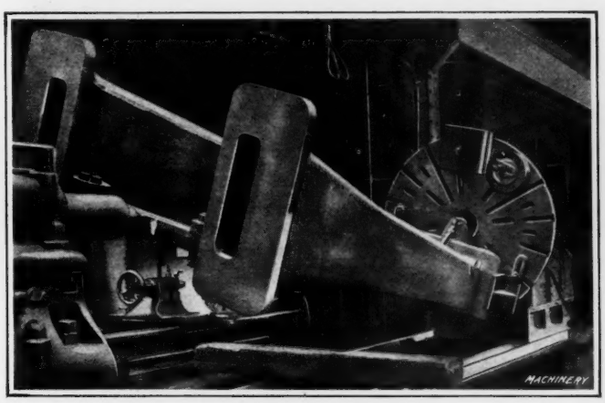

Fig. 19. Method of squaring Column Ends. It is a Common Practice to square these Castings up on a Planer

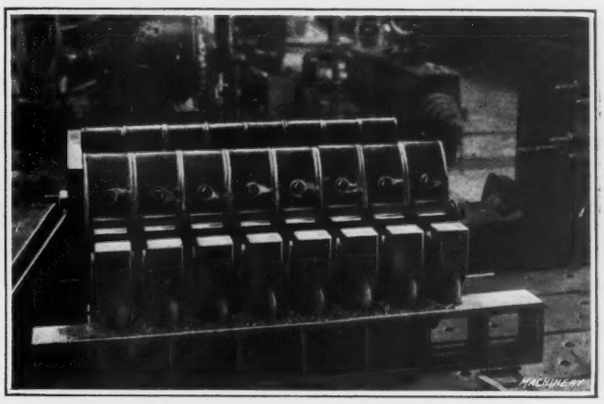

Fig. 20. Arrangement for planing Eight Horseshoe Bearings, thus reducing Time for Operation

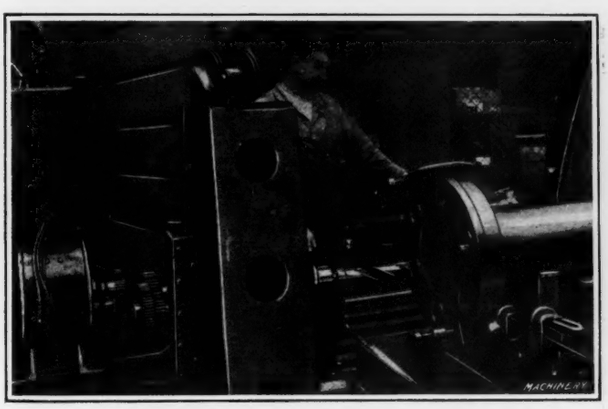

Fig. 21. Portable Machine mounted on Lathe for drilling and reaming Bolt Holes in Coupling Flanges

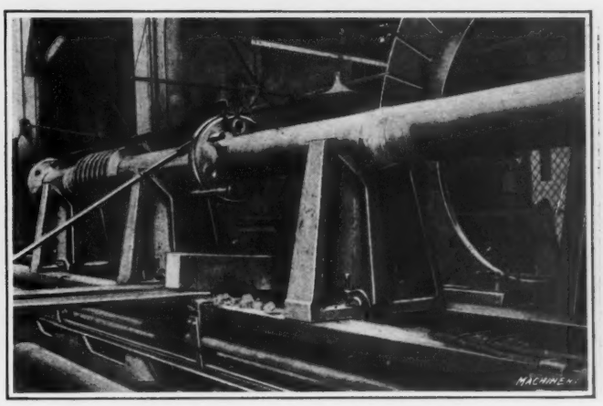

Fig. 22. Thrust and Tunnel Shafts lined up in V-blocks for finish-reaming Coupling Bolt Holes by Hand

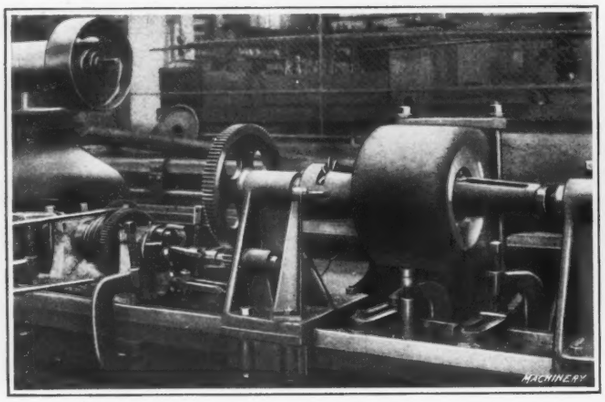

Fig. 23. Tapered Boring-bar mounted in Special Fixture that can be moved along Ways to Different Lugs on Work

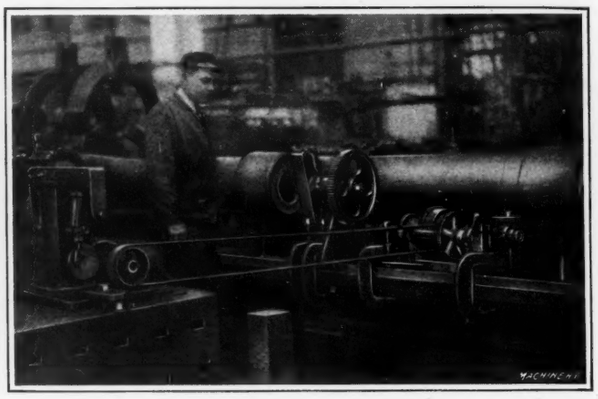

Fig. 24. Same Machine as shown in Fig. 23 with Facing Head installed for squaring up Faces of Lugs to provide Perfect Seating for Nuts

being planed as one solid block to the required shape. The holes for the dowels are drilled before the shims are separated. This method of making shims effects a great saving of time over individual machining.

bars and riveted over on the inside of the bar. The bars are planed in pairs on the radius planer attachment shown in Fig. 9. This method of planing links has been in use for many years and is very satisfactory. The link blocks are

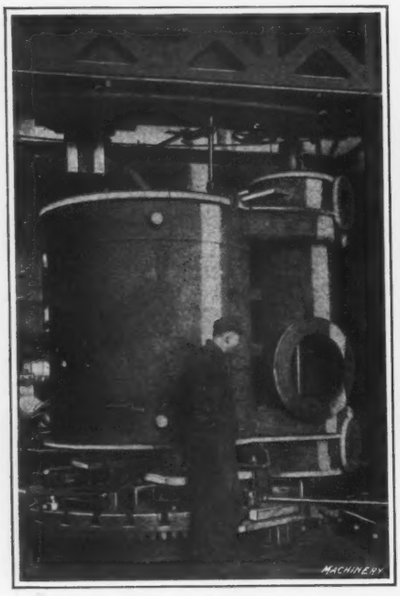

Fig. 25. Low-pressure Cylinder on Boring Mill. Cylinder Bore is finished and Valve Chest is being bored

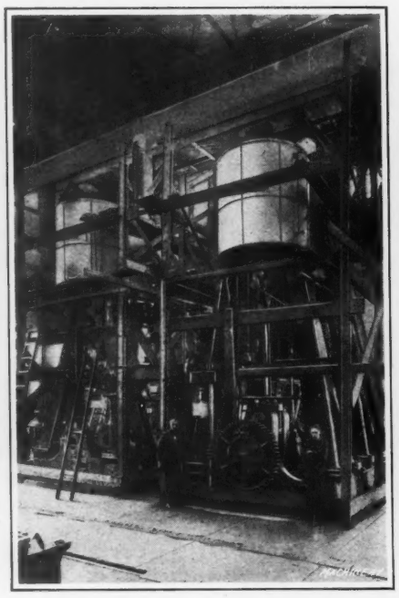

Fig. 26. Starboard Engine completed with Turning Gear installed as it will be under Actual Conditions of Operation

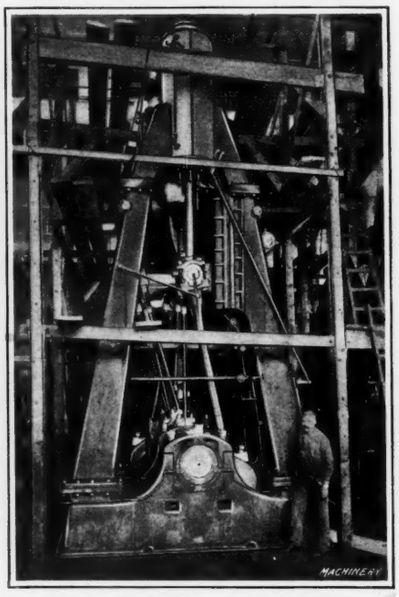

Fig. 27. High-pressure Cylinder End of Starboard Engine ready to be dismantled for Transfer to Ship

Engine Links, Shafts and Cylinders

The engine links are of the Stephenson double-bar type, bolted together onto thimbles with through fitted bolts. The general dimensions of the link bars are 1⅝ by 5¼ by 38 inches; the bars are finished all over and planed to a radius of 8 feet, 5 inches. The eccentric-rod pins are forced into the made from a one-piece billet planed to section, as illustrated in Fig. 10, which also shows the billets on the Newton cold saw being sawed up into six pieces. By this method time and labor are saved over rough-forging the six blocks and then machining them. Fig. 5 shows the completed block with the gibs secured, planed to the same radius as the link bars.

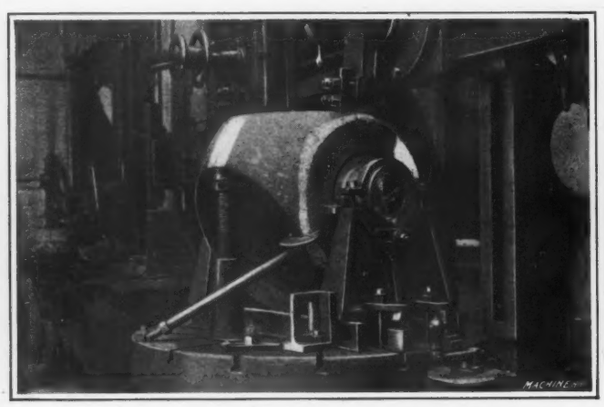

Fig. 28. Hub of Propeller with Shaft Hole bored and fitted with Cast-iron Arbor held in V-blocks to machine Taper Fits for Blade Seats

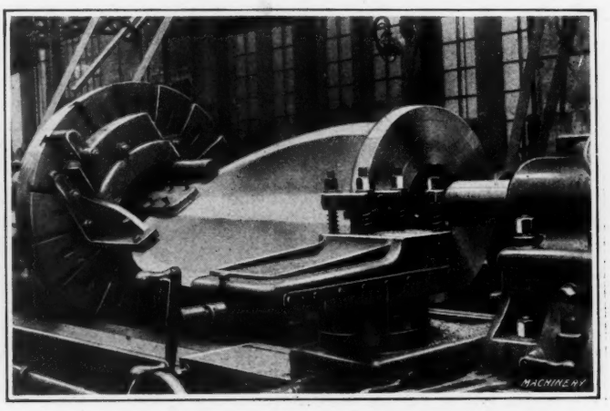

Fig. 29. Propeller Blade centered and set up in Lathe for facing and turning Tapers to fit Hub

The crankshaft is composed of fourteen pieces, which are assembled by shrink fits. It is 18 feet, 7¾ inches long, and weighs 20,600 pounds. The diameter of the journals is 12¼ inches, and of the crankpins, 12 inches. The three-throw cranks are set at 120 degrees, their sequence being high-pressure, intermediate-pressure and low-pressure. Fig. 6 shows the method of removing stock from crank-webs. Thirty-one holes, 1 1/16 inch in diameter, are drilled for the crankpin end, and thirty-three holes for the shaft hole. The thin webs left between the holes are easily parted by the use of a special broach, which is guided by the drilled hole, and carries a ⅛-inch cutter. By this method a 200-pound billet is pushed out, as shown in the illustration. Fig. 11 shows the webs, in pairs, secured to the slotter platen for the operation of rounding the ends and cutting the keyways. These webs are carried through to the finishing operations in pairs and are not released until completed. This insures perfect alignment when they are shrunk onto the pins. Fig. 12 shows the web mounted on a radius planing attachment, having a clearance cut at the top of the web. This is to facilitate feeling of the crankpin brass while in motion. In Fig. 13 is shown the crank assembled and set up on a lathe ready for the finish-turning of the journals and the eccentric seats.

In the manufacture of this crankshaft, the crankpins and webs are machined to finish dimensions before they are shrunk together, while the shaft, including the journals and eccentric seats, are finished true on centers after the parts have been shrunk and bolted together. This is to overcome any irregularities that may have developed during the process of heating and shrinking. The shafts run true to within 0.016 inch after being shrunk together. The heat for expanding the webs is furnished by two Hawk burners. The amount allowed for all the fit is 0.01 inch diameter.

Each engine has three cylinders. The high-pressure cylinder and the intermediate cylinder have one valve each, but the low-pressure cylinder has two; all the valves are of the piston type. The high-pressure cylinder is 20¼ inches in diameter; the intermediate cylinder is 37½ inches, and the low-pressure cylinder is 60¼ inches. Fig. 14 shows the low-pressure cylinder on the lay-out platen for inspection and establishing the centers and finished lines. Fig. 25 shows the same cylinder on the boring mill. In this case the cylinder bore has been finished and the valve chest is being bored with a 6-inch boring-bar, the cylinder remaining stationary and the boring-bar being driven by the boring and drilling attachment that is installed on the cross-rail of the machine. Great accuracy can be procured by boring the valve cages in this way, as the bar can be set parallel with the center line of the cylinder before starting the work. With this method the cylinder is bored, faced and drilled at one setting. Fig. 15 shows the high-pressure cylinder mounted on a large Bement & Smith horizontal mill. This machine permits boring, milling and drilling at one setting. The table on which the cylinder is secured can be revolved on its vertical axis to any desired angle, making any operation possible. Fig. 16 shows the method of cutting out the ports of the valve cages from solid metal; by this method clean castings and sharp port lines are produced.

Fig. 17 shows a babbitting space equipped with an oil-burning forge and iron bench and a one-half ton jib crane. On the bench are shown the horseshoes for the thrust, also the cross-head shoes and a form for the babbitting of the main bearings and caps.

In Fig. 18 is shown the beginning of the shop operations of erecting the engines; the three sections of the bedplates are shown bolted together and the columns are erected. On the starboard engine, the high-pressure cylinder is shown placed on the columns. The leveling of the bedplates is of the greatest importance in erecting engines of this type. In this case, a surveyor's transit was used to a good advantage, as the ordinary shop levels are not reliable enough for this work. Great accuracy in leveling foundations in the shop erecting is necessary, for most of the lining up of the various parts is obtained by the plumb-line. In placing these foundations on the erecting floor, they were set to the same lines and angles they would have when installed in the ship; this point was necessitated by the communicating shaft used for turning the engines. The lay-out of shaft centers on the ship was so perfectly done that these communicating shafts fitted without any change being made from the shop set-up. Fig. 26 shows the starboard engine complete with the turning gear installed. Fig. 27 shows the high-pressure cylinder end of the starboard engine ready for dismantling. These engines were finished in every detail, including oil-pipe, water cooling lines, indicator gear, counter and gages. Upon completion in the shop the engines were dismantled in three complete sections, the high-, intermediate- and low-pressures, loaded on flat cars, hauled to the fitting out pier, and reassembled in the ship.

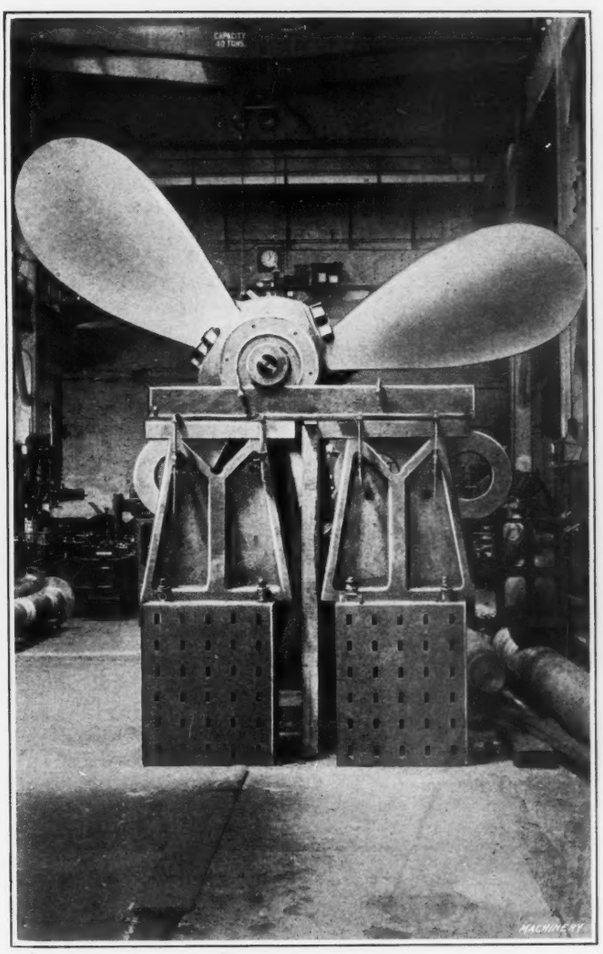

Fig. 30. Completed Propeller being tested for Balance preparatory to sending it on Board Ship for Erection

Fig. 19 shows the method of squaring up the ends of the columns that support the cylinders; these castings are in most cases squared on the planer, but the writer prefers the method shown, because it saves time and insures greater accuracy. The lugs for the center and cross-bar are cast on, and the 4-inch bar shown is secured with fitted bolts. The center holes are laid out and reamed on the lay-out platen before the columns are placed in the lathe. For the convenience of measuring the finished length of the column, a tram gage is used and all columns are finished to equal length. The length of the finished columns is 12 feet, and each column weighs from 4000 to 6000 pounds. Fig. 20 shows the arrangement for planing eight horseshoe bearings in one setting.

The shafting, the total length of which is 136 feet, 8 inches, is composed of the crank, thrust, tunnel, stern-tube and propeller shafts. The stern-tube shaft is entirely cased with a water-tight bronze sleeve. All outboard bearings on the shafting are of hard bronze and run in lignum-vitæ bearings, with the wood placed endwise. Fig. 21 shows a portable milling

machine mounted on the ways of a 60-inch lathe and used for drilling and reaming the bolt holes in the coupling flanges. An interchangeable drilling jig is secured to the flange and is centered by the outside diameter of the coupling. Fig. 22 shows the complete thrust and tunnel shafts carefully lined up in V-blocks for the purpose of finish-reaming the coupling bolt holes by hand. All coupling bolts are tapered and without heads, and are accurately fitted to the reamed holes.

Rudder Machining Operations

The machine operations on the rudder show an original and ingenious method of boring and facing the rudder pintel fits. The rudder weighs 18,000 pounds; its length is 23 feet, and its extreme width, 8 feet. Four pins are fitted into taper-bored holes, ordinarily called pintels. After stretching a piano wire through the cored holes and establishing the correct centers for the rudder to pivot on, the casting is placed on the ways of a large lathe and set central and parallel with the ways on one side of the lathe. Fig. 23 shows the tapered boring-bar mounted in a special fixture that can be moved along the ways of the lathe to the various lugs that are to be machined. It will be noticed that the bar is made tapering, the same as the pintel, and the tool is carried in a square groove and is fed with a screw and star feed. The power is furnished by a small air engine, and is transmitted through a 14-inch lathe headstock to the bar driving gear. Fig. 24 shows the same machine, with a facing head installed, squaring up the faces of lugs suitable for the perfect seating of the nuts. This method worked out satisfactorily with a small labor cost.

Machining Operations on Propeller

The two propellers were of the built-up type, with steel hubs and three bronze blades. Fig. 28 shows the hub with the shaft taper hole bored and fitted with a cast-iron arbor, which is mounted on a pair of V-blocks on the platen of a 60-inch boring mill for machining the taper fits for the blade seats. When one seat is finished, the hub is revolved 120 degrees and the next one is machined, until the three seats have been completed. Fig. 29 shows one of the blades centered and placed in a 48-inch lathe for facing and turning tapers to fit the hubs. Gages have been previously machined for calipering the diameter and gaging the angles. Fig. 30 shows the completed propeller being tested for balance.

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INDUSTRIAL DEVELOPMENT IN FRANCE

L. R. Duffield, of the Machinery Exhibition Department of the Philadelphia Bourse, sees evidence that France is preparing to become self-sufficient in machinery and machine tool manufacture, and even a competitor of the principal machine tool building countries, at the close of the war. In his opinion, France will have gained more industrially by the war than any other nation, not excepting America. She is buying millions of dollars worth of steel machinery and machine tools in the United States. The Bourse received inquiries for more than one million dollars worth within thirty days in the late summer, over half of which came from France, the remainder being from South American, Swedish and Norwegian firms. France plans to become industrially independent and to place "Made in France" products in international competition. She is bending every effort to become also a great dye, chemical and pharmaceutical manufacturing and exporting nation. A large part of her war industrial organization can be transformed for this purpose after peace is declared. She has gained a sense of confidence in her ability to manufacture, and her industrial organization is highly developed. Before the war the French were largely bankers, and silk, perfume and wine producers. Her leading men did not dream that she could become independent of Germany, England and America for her machinery and machine tool needs. Now they know different, and are preparing to act.

* * *

Because of the high prices of coal, the Honduras National Railway is forced to burn wood. In the past, when unable to obtain coal, the railway used coroza or cahoon nuts, but the intense heat these generated injured the boilers.

USE OF PULVERIZED FUEL ON LOCOMOTIVES[1]

When solid fuel is burned on grates in a modern locomotive, from 45 to 70 per cent of the heat is absorbed by the boiler. Most of that which is wasted is due to incomplete combustion, sparks, cinders, smokebox gases and combustible in the ash. Owing to the necessarily limited grate area, the high draft essential to induce sufficient air through the grates for combustion causes these enormous losses. Generally speaking, it is necessary to break up any fuel to such uniform size that the oxygen in the air can unite perfectly for combustion. For the best results, coal should be sized to about three-inch cubes, but as this is impracticable, because of methods of mining and the cost, a mixture of fine and large coal is usually supplied, which tends to burn irregularly and results in a reduction of boiler capacity and efficiency. A one-inch cube exposes but six square inches of area for absorbing oxygen and liberating heat, but when pulverized to the proper fineness it will expose from twenty to twenty-five square feet; hence the first essential for complete combustion is the breaking up of the fuel into dry, minute and uniform particles. Then by diffusing these so that each may be surrounded with the right quantity of air, it will be possible to burn practically all the available combustible. Any solid fuel that, in a dry pulverized form, has two-thirds of its contents combustible, is suitable for pulverizing, and to produce the best results should be mechanically dried and milled so that it will be of about the same dryness and fineness as portland cement.

In the process of burning pulverized fuel, the fuel in the enclosed tank provided for the Muhlfeld system gravitates to the conveyor screws, which carry it to the fuel and pressure-air feeders, where it commingles with the air. It is then blown through the connecting hose to the fuel-and-air delivery nozzles and blown into the burners. Additional air is supplied and the mixture is drawn into the firebox by the front-end draft. More air is supplied in the furnace where complete combustion of the fuel in suspension takes place. The liquid ash runs down the under side of the roof, sides and ends of the furnace, and is precipitated into a self-cleaning slag-pan, where it solidifies into a mass that can be readily dumped. The blower is driven by a constant-speed turbine which requires no regulation or control. The fuel conveyors, feeders and comminglers are driven by a variable-speed steam turbine which is controlled by the fireman.

The waste of fuel from the stack, where coal having a large percentage of dust and slag is used; the lowering of the firebox temperature and draft, due to opening the fire door; and the resultant variation in steaming and general results under high rates of burning fuel on grates, are entirely eliminated. With pulverized fuel a locomotive having the boiler filled with cold water may be brought under maximum steam pressure within an hour, and the fuel feed then stopped until it is needed for service. When standing or drifting, the fuel feed can also be discontinued, as the steam pressure can always be quickly raised. From the actual operation of steam locomotives, the use of pulverized fuel has demonstrated in particular the practicability of eliminating smoke, cinders, sparks and fire hazards; increasing draw-bar horsepower per hour per unit weight; reducing non-productive time at terminals; improving the thermal effectiveness of the locomotive as a whole; utilizing otherwise unsuitable or waste fuels; eliminating arduous labor; providing greater continuity of service; and producing more effective and economical operation and maintenance.

* * *

The coefficient of friction of solid rubber tires on cement and vitrified brick roads is about 0.6, while that of pneumatic tires under similar conditions is 0.5. The coefficient of adhesion is greater than that of friction and incidentally this partly explains why a motor car stops more rapidly when the wheels are kept moving than when they are locked; hence the increased danger when a car skids if the rear wheels are locked by the brakes.

[1]Abstract of a paper read before the Minnesota Section of the A. S. M. E., March 10, 1917, by John E. Muhlfeld, New York City.

JIGS AND FIXTURES FOR MILLING AND ASSEMBLING

FEATURES OF DESIGN OF SOME SPECIAL FORMS

BY S. HELWEG[1]

IN manufacturing interchangeable parts, it is necessary to have a complete set of tools and gages. The two chief factors in designing these tools are the construction and the cost. Much thought should be given to the construction, as the quality and cheapness of the parts to be manufactured largely depend on the tools. Care should be taken to lay out the jig or fixture in such a way that the parts to be machined will be properly located, and so that the operator who uses the tools cannot get the work in wrong and thus spoil the parts. The fixture should be easily loaded and unloaded, and it should be as open as possible, to make cleaning easy and to prevent

[1]Address: 260 Gold St., Brooklyn, N. Y.

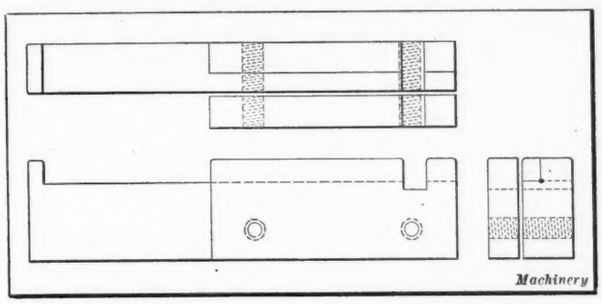


Fig. 1. Detachable Vise Jaws for Use in cutting off Bar Stock

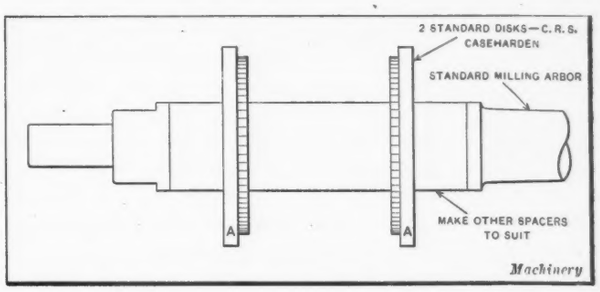


Fig. 2. Arrangement of Cutters used with Fixture shown in Fig. 4

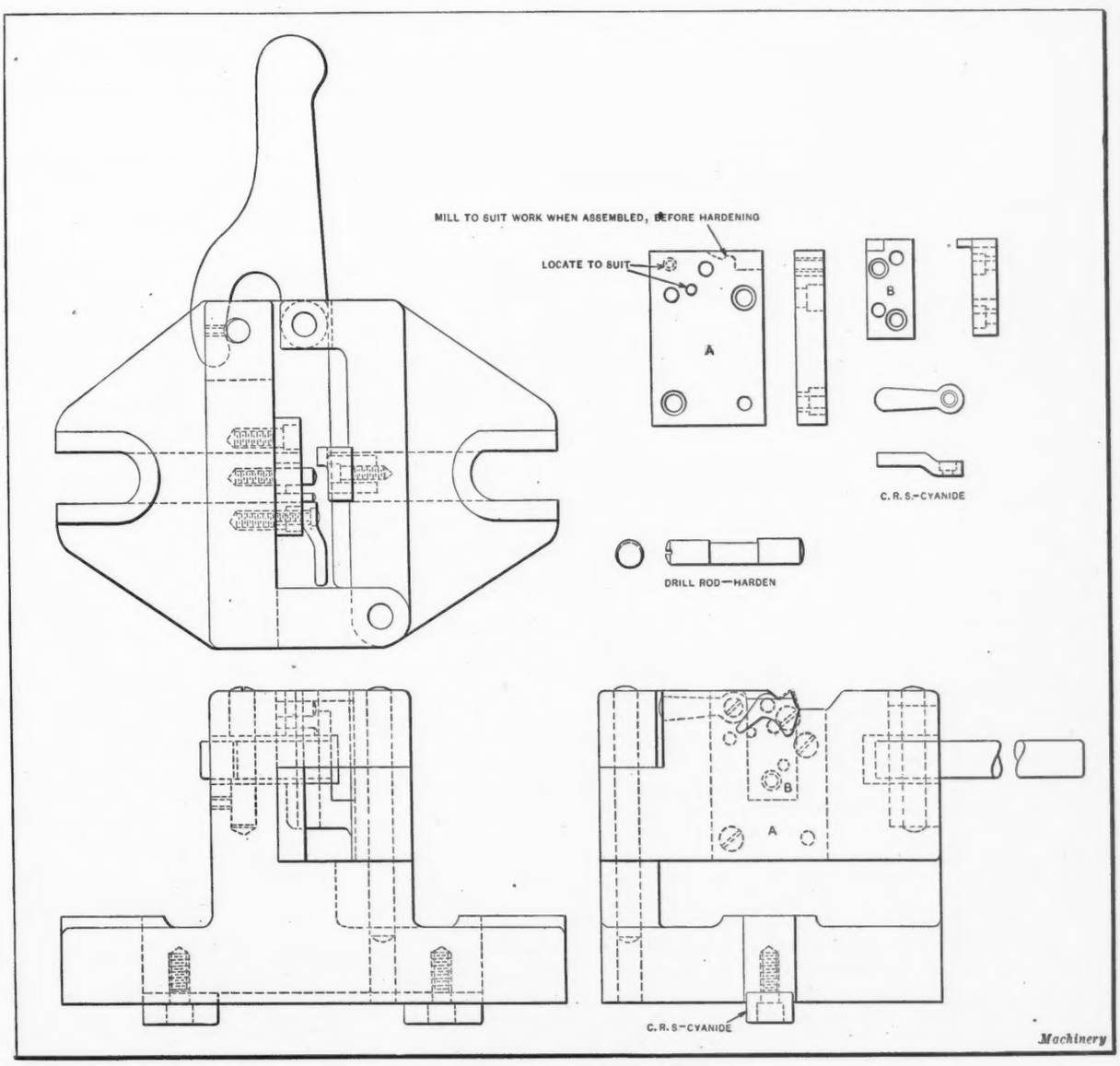


Fig. 3. Fixture for holding Work while milling Point

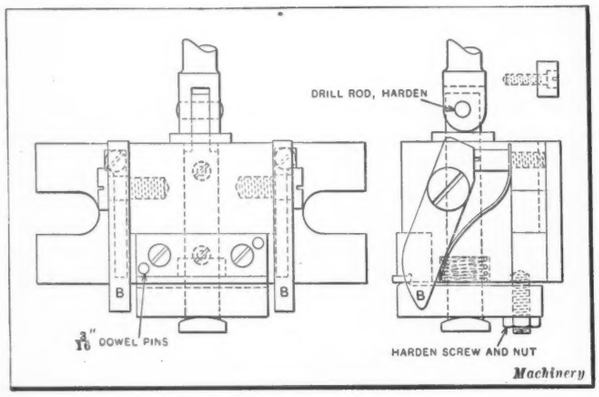


Fig. 4. Straddle-milling Fixture

pockets for chips. Hardened steel seats should be ground parallel with the base after assembling to obtain the best results. To bring the cost as low as possible, the tool parts should be standardized wherever practicable. Jig bodies and fixture bases should be made of cast iron and kept in stock in various sizes to meet the requirements of the shop. Clamping cams, dowel-pins, bolts and screws should be made up in large quantity, and steel seat blocks, straps and other steel parts should be made of standard stock sizes, if possible, to prevent unnecessary machining.

The cheapest kind of milling fixture that can be built is a pair of detachable vise jaws, as shown in Fig. 1. These jaws are made of cold-rolled steel and casehardened. They can be removed from the vise quickly and replaced by other jaws. It is advisable, however, to use vise jaws only where great accuracy is not required, such as when cutting to length or milling clearance cuts. The jaws here shown are used for cutting off pieces from a bar of stock, which is pushed up against the stop and then cut off to the desired length.

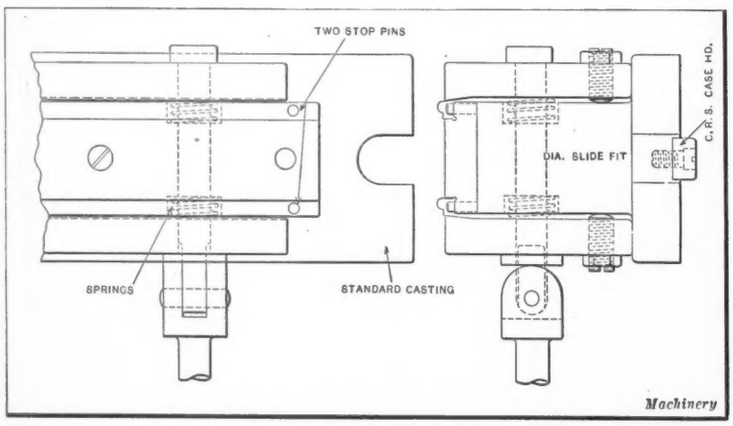


Fig. 5. Fixture for machining Two Parts in One Operation

In Fig. 3 is shown a standard milling fixture where the part to be machined is located on a stud and held against a stop-pin by a small cam; then the fixture leaf is closed and the work is held in place ready for milling. The base, leaf and cam are made of cast iron. These fixtures should be machined and fitted in large quantities, with the exception of steel seat block *A* and clamping block *B*, which are made to suit the job in hand.

When accuracy in length is essential, a fixture like the one shown in Fig. 4 can be used to advantage. The part to be machined is cut to the approximate length in vise jaws or with a power hacksaw and then straddle-milled in the fixture. Here it is located between the two pawls *B* and clamped in place by the strap and cam. On the arbor shown in Fig. 2 are mounted two steel disks *A* about ¼ inch larger in diameter than the two side milling cutters. When the fixture is fed underneath the arbor, these disks depress the pawls and give clear passage for the cutters. On the same arbor can be mounted other cutters to suit the work. This arbor should never be taken down, as it is important that the distance between the straddle-mills be kept constant; the cutters should be ground on the arbor.

The milling fixture shown in Fig. 5 is made for machining two parts in one operation. On the cast-iron base is mounted a double seat block and the seats are ground after assembling. The parts to be milled are clamped in place by cam binders at each end and two straps. By using set-screws in the straps, accuracy in making the cams is not necessary, and wear on the cam faces can be taken up by these adjusting screws. The fixture shown in Fig. 6 is very effective, as the strap can be pulled back out of the way, leaving the whole seat block uncovered, so that a brush can be easily inserted for cleaning, when necessary.

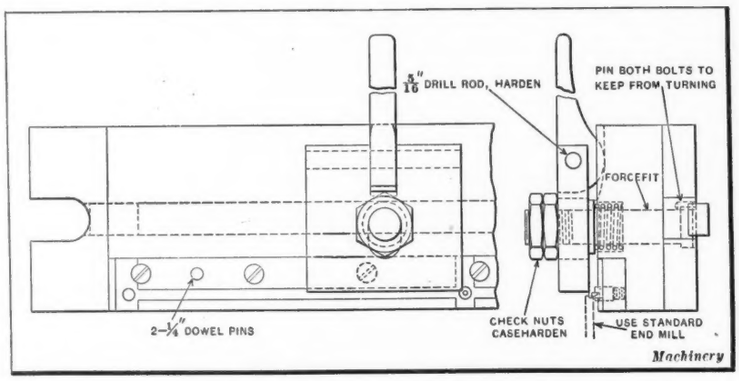


Fig. 6. Fixture that can be easily cleaned

Assembling Fixtures

When assembling different parts, hand-riveting should be avoided wherever possible, foot-presses or small power presses being used with suitable fixtures. In Figs. 7 and 9 are shown simple but effective riveting punches and dies to be used in presses. First, the hub is assembled with the lever. The hub is seated in a hardened steel bushing and staked over with a plain 60-degree point punch. After assembling, the shoulder rivet is secured in place with a star riveting punch. As the head of the rivet is flattened on two sides, it is necessary to locate the two parts in the right relation to each other. This is done by mounting the lever on a pin and locating the rivet on a stud, where a milled groove brings the rivet in the right relation to the center of the lever.

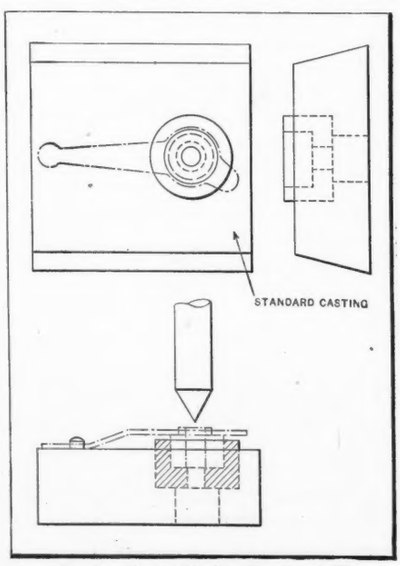


Fig. 7. Simple Riveting Punch and Die

A riveting fixture with a self-contained punch is illustrated in Fig. 10. The part to be assembled is located on a pin and the head of the stud rests in a recess in the steel anvil. This

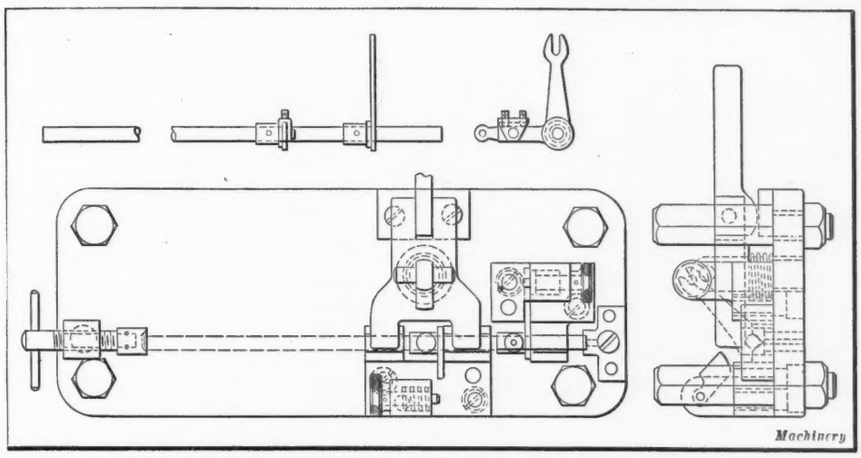


Fig. 8. Open Assembling Jig for drilling and reaming Holes for Taper Pins

fixture can be used both in a press and for hand-riveting, as the punch is always in line with the stud to be riveted.

When pinning one or more levers and arms on a shaft, it is necessary to design assembling drill jigs for locating the different parts in the right relation to each other and at the right distance from the end of the shaft. Two jigs for this purpose are shown in Figs. 8 and 11. One is an open-style jig, where the drilling is done through bushings in the base; the jig is then turned over and the holes taper-reamed from the open side, after which the parts are pinned. The other is a leaf jig, where the shaft is clamped by the leaf and the bushings are located in the leaf. When taper-reaming and pinning, the leaf is opened. The illustrations show clearly how the parts are located in the right relation to each other.

* * *

Three million feet of mahogany and black walnut will be required for the propellers of the aeroplanes America is expected to build in its first year at war.

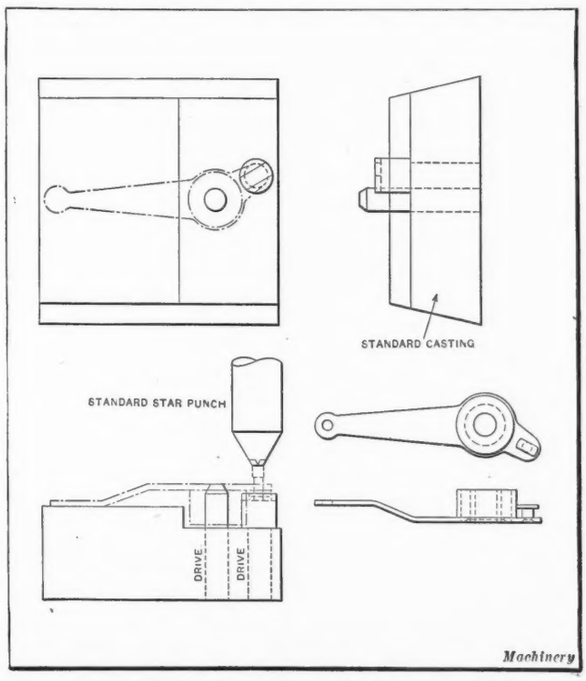


Fig. 9. Another Type of Simple Riveting Punch and Die

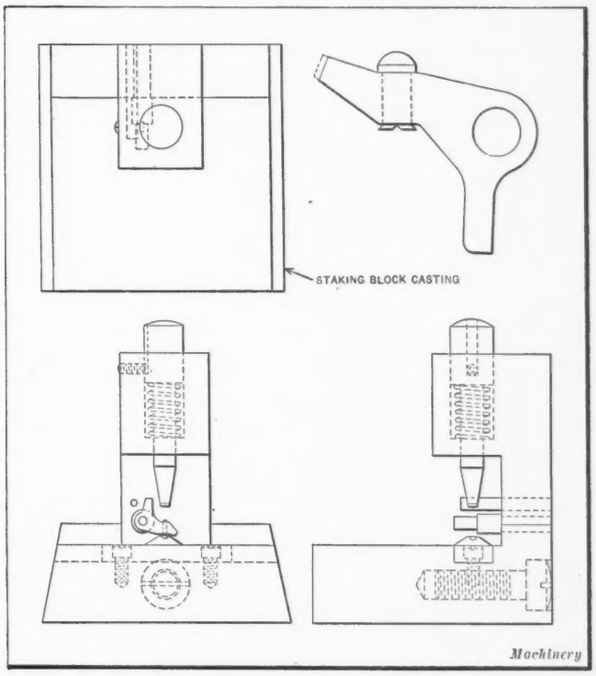


Fig. 10. Self-contained Riveting Fixture

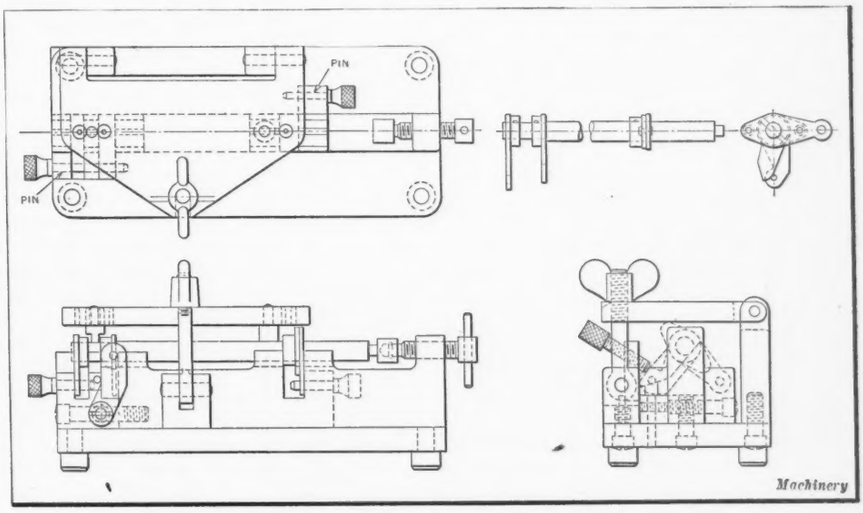


Fig. 11. Leaf Assembling Jig for drilling and reaming Holes for Taper Pins

ELECTRICAL EXPORTS

American electrical apparatus is gaining rapidly in popularity the world over. The value of electrical machinery, appliances and instruments exported from the United States in the fiscal year 1917 aggregated more than $50,000,000, against $20,000,000 in 1914, $10,000,000 in 1911, and $6,000,000 in 1900. Of the telephones exported (nearly $2,000,000 worth), more than $100,000 worth went to Asia, about an equal value to South America, nearly as much to Oceania, $300,000 worth to our North American neighbors, and practically $1,000,000 worth to Europe. The total value of telephones exported in 1917 was twice as great as in 1912. The largest market for electric fans was India, while the Straits Settlements, China, Japan, and even Siam imported a large number. The total exports of electrical apparatus of all kinds in 1917 was nearly ten times as much as in 1910 and thirty times as much as in 1900.

DESIGNING AND CONSTRUCTING A CLOCK

BY GUY H. GARDNER[1]

The accompanying illustrations show how a machinist, with scant knowledge of horology, designed and constructed a timepiece whose running compares favorably with that of "regulators" costing $100 or more. The construction is ordinary lathe work, but the designing called for some knowledge of escapements and compensating pendulums, which were supplied by a friendly watchmaker. As the machinist had no gear-cutting facilities, he was obliged to use stock gears, the pitch of which is coarser than that used in most high-grade clock trains, and the performance of the clock has led him to suspect that undue importance is sometimes attached to fineness of pitch. The high cost of brass led to the use of sheet steel for the plates, bushings of phosphor-bronze being inserted for the pivots to run in. The bushing holes were reamed with what the watchmaker calls a "broach"—a five-sided reamer—and finished with a similar round tool used with oil.

In Fig. 1, *S* denotes sprocket wheels. The large wheel *A* has 240 teeth; the center wheel *B*, 120 teeth; the center pinion *C*, 20 teeth; the third wheel *D*, 72 teeth; the third pinion *E*, 12 teeth; and the escape pinion *F*, 12 teeth. All these are 48-pitch brass gears. The sprocket marked S_4 has its arbor squared on the front end for a key. The arbor carries a ratchet wheel, and a pawl prevents backward rotation; it winds right handed. The motion work, or "back-gears," shown in Fig. 2, consists of the cannon *A* for the hour hand; the hour wheel *B*, which has 60 teeth of 32 pitch; the minute pinion *C*, which has 20 teeth of 32 pitch; the minute wheel *D*, which has 96 teeth of 48 pitch; the cannon pinion *E*, which has 24 teeth of 48 pitch; and the center staff *F*.

For both ends of the center staff and the escape-wheel staff, which carry the minute and the second hand, respectively, the bushings have a simple straight hole, with a countersink to hold oil, and are without caps. For all other pivots, the bushings are made as in Fig. 3 and are capped with thin disks of hardened steel; this form of bushing causes the oil to be held by capillary attraction about the end of the pivot. These pivots are coned on the end, and are allowed about 0.020 or 0.025 inch end shake. This arrangement makes it possible for the clock to run at least two years before requiring cleaning and fresh oil. The disk *S* is tool steel, hardened and surfaced bright. It is held by fillister-head screws, not shown, the heads of which overlap the disk.

[1]Address: New London, N. H.

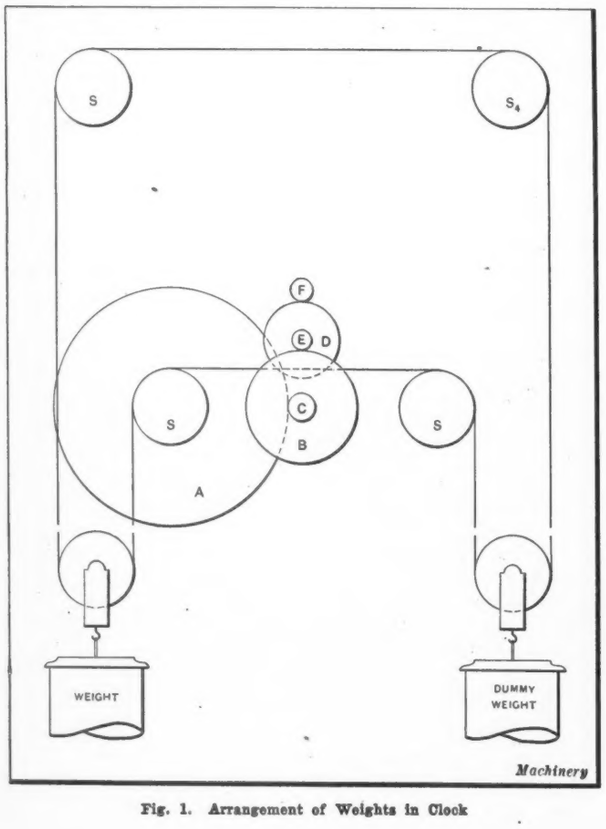
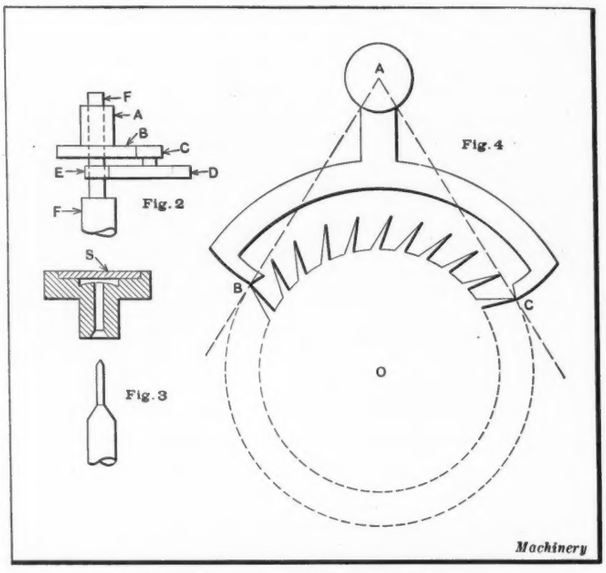


Fig. 1. Arrangement of Weights in Clock



Figs. 2 to 4. Important Details in Clock Construction

The escapement presents no difficulties after its underlying principles are comprehended. As Fig. 4 shows, the center distance between the escape staff and the pallet arbor is readily determined, either by calculation or by lay-out, as it depends solely on the outside diameter of the escape wheel and the number of its teeth embraced by the pallets. As is usual in clocks beating seconds, this wheel has thirty teeth, of which the pallet embraces ten. As lines *AB* and *AC* are tangent to the circumference of the wheel, it is easy to determine the center distance *AO* and the radii for laying out the locking "planes." The "lift lines"—the beveled edges of the pallet—are at an angle of 30 degrees to the tangents *AB* and *AC*. The so-called locking planes of the pallet are not planes, but, as in all "Graham" escapements, are curved surfaces that have the same axis as the pallet arbor. The pallet is of tool steel, hardened, and the locking surfaces are lapped in the lathe, the pallet being mounted for this purpose on a stud carried by the tool-block.

In all high-grade clocks there has to be some device to keep the movement running during the winding, as otherwise several seconds will be lost each week. For this purpose a spring-driven "maintaining power" is usually employed, but in the present design this is unnecessary, as the drive is by an endless sprocket chain, and the act of winding the clock does not interfere with its operation. The clock was designed to be wound by a key and to run eight days. However, the builder has attached an electric device whereby a small motor winds the clock at the end of every hour for another hour's running, but this is not an essential part of the design. It was added, the owner says, "just to make the clock complete." If the motor or the battery should fail to perform its function, the clock will continue to run until the end of the week.

The pendulum rod is well-seasoned, straight-grained, white pine, and is thoroughly shellacked. It is of elliptic cross-section, except for about 14 inches at the bottom, where it fits a square brass tube running through the center of the bob. The adjusting screw below the bob is cut thirty-six threads per inch, and the nut has thirty graduations to facilitate regulation; one graduation corresponds nearly to one second in twenty-four hours.

The bob is of 1¾-inch brass tubing, about 12¾ inches long, and is filled nearly to the top with shot; the exact quantity must be determined by experiment, as will be explained later. The weight and also the dummy weight on the opposite loop of the chain are of the same tubing. This dummy is added solely for appearance's sake, and both weights, like the pendu-

lum bob, are plated with nickel. The driving weight contains about two pounds of lead. As all the staffs are of drill rod, the pivots ground after hardening, and the whole train carefully constructed, a much smaller weight will drive the clock, but it was thought best to allow an ample margin.

The case is made of birch, finished to resemble mahogany; it is of unusual strength and solidity. The back is of hard wood, 1½ inch thick, with two strips of ½- by 1½-inch steel set into gains to prevent warping. These strips carry the studs to which the movement is held by a "three-point" fastening, while the piece that carries the suspension spring of the pendulum is bolted to the upper one. The axis of the pallet arbor, produced, would pass through the under surface of the "chocks" holding the pendulum suspension. The dial is 12 inches in diameter.

The compensating property of the pendulum depends on the fact that lead has a higher coefficient of expansion than wood, and its adjustment was effected in the following manner: When the clock was otherwise completed, the pendulum bob was filled with shot to a depth of 11½ inches and the clock run for several days in a room open to the winter air. Its rate having been found and recorded, the room was warmed and a run of an equal number of days showed that the compensation was inadequate, as the clock ran more slowly in the warm room. More shot was accordingly added to the bob and the trials in cold and heated rooms repeated. This tedious process was continued until satisfactory compensation was attained, after which the regulation by the nut at the bottom of the bob finished the job.

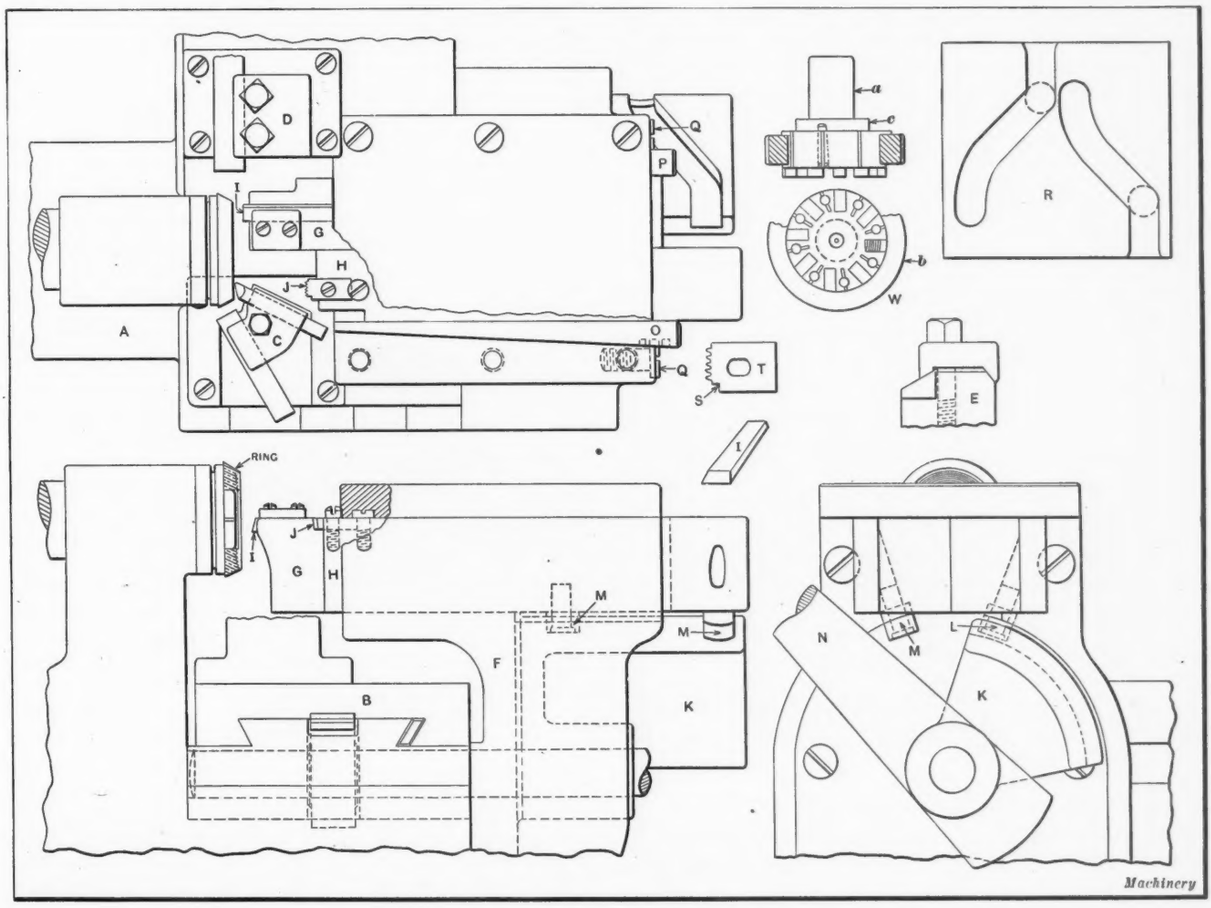
* * *

An alloy for soldering cast iron, melted steel, aluminum, etc., recently patented, consists of twenty-five parts each of lead and tin and fifty parts of zinc. After the articles to be soldered are cleaned, they are covered with stearic acid, or similar flux, and the alloy is applied with an extra hot soldering copper.

RING TURNING, FACING AND SERRATING MACHINE

BY DONALD A. BAKER [1]

The accompanying illustration shows the details of a simple special machine for completely finishing the bottom ring of the Type 80 time fuse after it has been reamed and one side has been faced. The capacity of the machine is from 3500 to 4000 finished rings per ten hours, as it can be run continuously. The spindle does not have to be stopped when putting on or taking off the rings. The frame of the machine *A* is mounted on cast-iron legs. The cross-slide *B* is similar to that used on turret lathes, but of a much more rigid construction. In a tool-block *C* in the front of the cross-slide are mounted the rough-turning and rough-facing tools; these are regular high-speed tool bits. At the back of the cross-slide is mounted the finish-shaving tool *D*. An end view of this tool and its holder is shown at *E*. Attention is called to the clamp, which holds the tool down and also draws it back against the holder. Instead of being tangent to the work, the tool is held at an angle



Ring Turning, Facing and Serrating Machine

of 5 degrees and is intended to stop just a little behind the vertical center line of the work.

A substantial bracket *F* is bolted to the lower half of the cross-slide and to the frame of the machine. The top part of this bracket is planed out to receive the two tool-slides *G* and *H*. One of these slides *G* carries a roughing tool *I* that removes most of the stock and prepares the face of the ring for the serrating tool *J*, carried by the other tool-slide *H*. These two slides are operated by a segment of a drum cam *K* which bears against two hardened tool-steel cam rollers *L* and *M*, which are held on studs secured to the tool-slides. The cam is actuated by a hand-lever *N*. This lever, the cam and a gear that engages with a rack on the top half of the cross-slide are keyed to the same shaft, so that all the tools that work on the ring are operated by this lever.

The front angle roughing and facing tools are brought up

[1] Address: Layman Pressed Rod Co., 1790 Broadway, New York City.

to the work at the same time that slide *G*, carrying its tool *I*, moves forward, so that all three tools are presented to the work at the same time. When the hand-lever *N* is pressed down, these tools are moved back and the angle shaving tool *D* and the serrating tool *J* are moved forward to do their work. The hand-lever *N* is then brought back to a neutral position, when all the tools are out of the way sufficiently to allow of the ready removal of the ring. A lay-out of the cam used to actuate the tool-slides is shown at *R*. The two tool-slides *G* and *H* are held sidewise by the taper gibs *O* and *P*. These gibs are adjustable and are held in place by hardened screws *Q*, the heads of which enter slots in the sides of the gibs.

An enlarged view of the serrating tool is shown at *T*. This is made from high-speed flat stock and is held in place by two screws, as shown. An elongated hole allows a slight adjustment to be made by placing thin shims of steel behind the tool. The step *S* in the tool takes care of the depth of the serrations from the top of the ring, as it faces off the top at the same time that the serrating is being done, and assures that all rings will gage correctly at this point, providing the tools are made right.

The novel method of making these serrating tools is illustrated at *W*. A mandrel *a* is first turned up, good centers being left in the ends. Next slots are cut in the circumference, into which the serrating-tool blanks, which have been milled to size on two sides and one edge, can be placed. These slots are of a uniform depth and hold the tool in the same relative position that it will have in the tool-slide. Then holes are drilled and reamed to take taper pins, as shown, and narrow saw slots are cut down through the center of each taper-pin hole, so that when the tool blanks are tapped into place, pins driven into the holes will wedge the metal on each side over against the tool blanks and hold them securely while the outside and the step are being turned. As extra support, a close-fitting ring *b* is forced on over the arbor to hold the tool blanks while they are being formed on the face and backed off. This last operation is done by holding the arbor in a special chuck and backing off the tools by using the lathe backing-off attachment. A collar *c* is screwed onto the arbor *a*, against which the back end of all the cutter blanks rest, thus holding them in a uniform position.

While this machine was designed for the bottom ring, it may be used for the top ring with equally good results, but in that case only one tool-slide is required for finishing the top of the ring, as there is no serrating to be done. While the machine as a whole somewhat resembles a turret lathe, every detail is of much more rigid construction, especially the spindle, the cross-slide, and the tool-slides, there being as little overhang in all parts as possible, and no indexing of a turret with its accompanying inaccuracies to contend with.

* * *

DETAILS OFTEN IGNORED

BY GEORGE F. KUHNE[1]

In performing certain work, we sometimes disregard the minor points, which, if they were recognized, would aid in attaining the desired end; and this is not only true of the successful executive, but of the bench hand, machinist and worker in general. For instance, in putting a set-screw into a pulley, bolster, or whatever the case may be, there is seldom thought given to how the set-screw is to be removed later. Or, perhaps, a nut on some part of a machine that is exposed to the weather must be removed. If the nut is stubborn, the hammer and chisel will very likely be resorted to; and if the nut should not respond (the corners having been chipped off), perhaps the Stillson wrench is applied. Had some heavy oil been put on the screw when the nut was screwed in, all this fussing and waste of time and energy might have been avoided. A few drops of oil in cases of this kind will help, but it is so small a matter that many mechanics never think of it.

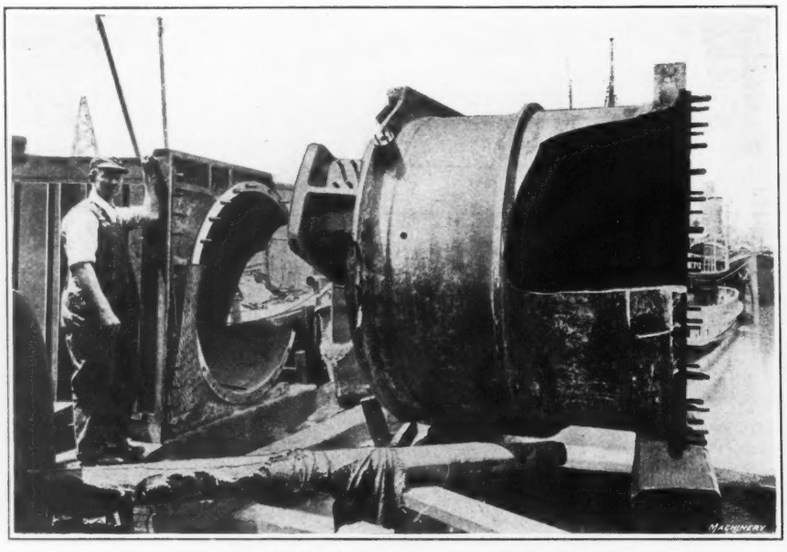
Sometimes difficulty is experienced in piercing stock and a number of punches are broken; but if the steel for the punch is forged or hammered slightly, allowed to cool, turned to size and hardened in the usual manner, better results are frequently obtained. Also, if in the making of a punch for redrawing shells, tubes, etc., the piece of steel is heated, one end placed on an anvil and the other end hammered, it will be less likely to bend in hardening; but this must be done before the hole is drilled for the escapement of air; otherwise the punch may be bent after hardening as much as it usually is when this plan is not used.

[1]Address: 44 Washington Place, E. Rutherford, N. J.

* * *

AN EXAMPLE OF "GERMAN EFFICIENCY"

In one of our Atlantic shipyards these two cylinders lie, just as they were taken out of one of the interned German liners, and they show how "German efficiency" was applied in destroying these castings before the boats were seized by the American government. The cylinders are about five feet in diameter and the sections were broken out by driving heavy wedges in the cap bolt holes and at the same time applying a turnbuckle bar across the diameter of the cylinder to help break out the sections between the wedges. One of these wedges may be seen where it was left in a bolt-hole at the extreme right of the illustration. To repair this damage is several months' work, because new patterns must be made, the cylinders cast, and then machined and installed in the boats. But an accurate record will be kept of all this work, and it will be charged against the ship and held for "the day of reckoning."



Broken Cylinder Castings from a German Liner

* * *

The manufacture of special wire nails coated with a rosin compound for use in box nailing machines is a small but important branch of the nail making industry. Box nails are tumbled to remove burrs from the heads and are carefully inspected, all crooked or defective nails being rejected. They are then coated in revolving drums with the rosin compound, and are packed in kegs containing between 70 or 80 pounds. Each keg is marked with the number of nails it contains instead of the weight, being sold by count instead of pound. The rosin compound considerably increases the holding grip of the wood on the nail and permits the use of smaller nails for a given purpose. This is important in boxes made of thin lumber, as the small nails are not so likely to split the thin material. Careful inspection is necessary to eliminate defective nails that stop the nailing machines and reduce production.

WORK-HOLDING ARBORS AND FIXTURES

DEVICES FOR HOLDING AND CLAMPING WORK ON THE FELLOWS GEAR SHAPER

BY DOUGLAS T. HAMILTON [1]

THE methods of holding work on the gear shaper differ from those used on practically all other machine tools, especially other gear-cutting machines. The reasons for this difference are the peculiar design of the work-arbor and the construction of the machine as a whole, which is such that, with a properly designed work-holding fixture, the gear being cut can be rigidly supported. There are, of course, certain fundamental points that are of vital interest to those using the gear shaper, a few of the more important of which are here described.

A characteristic of the gear shaper that is not at first appreciated is the fact that it has a considerably greater range than appears at first sight. The capacity for diameter is 35 inches and for stroke 5 inches; but many modifications are possible, such as increasing the distance between the face of the work-spindle and the extreme lower or upper point of the travel of the cutter, and enlarging the hole through the work-spindle. The column is raised by inserting blocks beneath it, and when long-shank gears are to be held, a work-spindle having a larger hole through it is used. These particular points are mentioned, as a clear understanding of the modifications that can be made is necessary to fully appreciate some of the fixtures and work-holding outfits that will be described.

Fig. 1. Reverse-taper Work-arbor used on Fellows Gear Shapers

Design of Standard Work-arbor and Work-spindle

The work-arbor used on the gear shaper, shown in Fig. 1, is of the reverse-taper type. It differs from all other work-arbors in this respect that the tighter the work is clamped to it the more rigidly is the arbor held in the work-spindle. This can be seen from Fig. 2. By tightening the nut on the top of the work-arbor, the latter is drawn up into the corresponding taper in the work-spindle, and the work is, in consequence, bound tightly to the top face of the work-spindle. With this arrangement, it is evident that, with a work-arbor that runs true, properly machined gears can be held rigidly without springing the arbor; but if the faces of the gears are not true with the hole, the arbor will be sprung out of alignment with its true vertical plane. Instead of being a disadvantage, this point is one of the good features of the gear-shaper work-arbor, because gears that are not machined true might give trouble in assembling. The gear shaper reveals defects in the previous machining operations.

In order to test whether the gears are accurately machined or not, the first step is to clean the arbor and spindle thoroughly, and then insert the arbor in the work-spindle from the lower end. The arbor is then tested for truth, as shown in Fig. 3. If it is found to run out slightly in the first trial, it should be given a quarter turn in the spindle, as a speck of dirt may be holding it out of line. When the arbor runs true, the gear blanks are put on it, as shown in Fig. 4, and rotated by hand; this tests the concentricity of the hole with the outside circumference. A dial indicator, as shown, is used to make this test. The reading for eccentricity on the indicator is noted, and then the nut is tightened down on the work, clamping it rigidly in place.

Another test is now made, as shown in Fig. 5. If the work runs out more than it did in the previous test, it is clear that the faces of the gears are not true with the holes, and that the work-arbor has been sprung out of its true vertical plane. If the difference between the two readings exceeds the manufacturing tolerance on the gears for eccentricity, the gears should be refaced before being cut. This test is especially necessary when setting up a new batch of gears, as it eliminates troubles that might crop up in subsequent operations.

The Swinging Apron

Another characteristic feature of the gear shaper is the swinging work-apron, which permits the easy insertion and removal of the work. Work up to the full capacity of the machine for diameter and face width can be easily mounted on the arbor by simply opening the apron and swinging it back clear of the machine. Advantage is sometimes taken of this swinging feature of the apron in connection with the machining of pinions or gears integral with a shaft. The apron can be swung clear of the machine and the pinion dropped down into it. The maximum diameter of shaft that can be handled is 5 inches, but the only limitation for length of shaft is the distance between the top face of the work-spindle and the floor, and by cutting a hole in the floor to clear the shaft this limitation is eliminated. The other features of the apron are not directly connected with the methods of holding and clamping work, and so will not be described here.

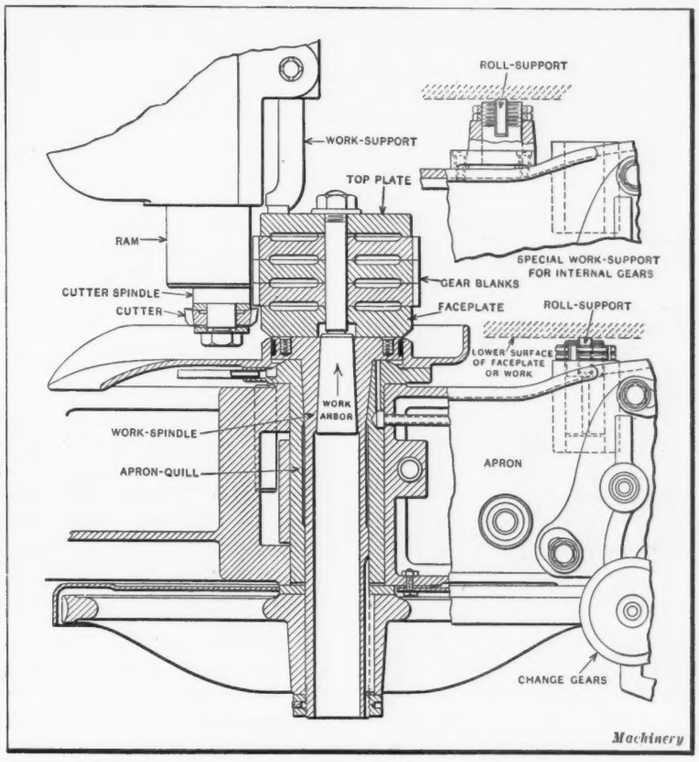


Fig. 2. Section through Work-spindle and Apron showing Construction

Work-support on Saddle

The gear-shaper cutter can be made to operate on either the "pull" or the "push" stroke. When the pull stroke can be used, this method is preferable, because of the reverse-taper work-arbor. The pulling up of the work, which is the result of using the pull stroke, is overcome by the resistance of the reverse-taper work-arbor. As an additional support, a work-support carried on the saddle, as illustrated in Fig. 6, rests on the surface of the top plate or on the work, if the latter has a smooth, plain surface, and transfers all vibration or thrusts to the frame of the machine, where it is taken up by the massiveness of the construction. Another feature of the work-support is that it can be

[1] Address: Fellows Gear Shaper Co., Springfield, Vt.

placed directly over the thrust of the cutter, and thus prevents not only chattering but also any springing tendency of the work-arbor. Whenever possible, the work-holding fixtures should be mounted so that the work-support can be used, as this adds greatly to the rigidity with which the work is held.

Work-support in Apron

Another work-support is held in the apron, as shown in Fig. 2; this is used for supporting large faceplates or internal gears. It is of especial advantage for supporting internal gears which, as a general rule, must be cut by the push stroke, in which case the thrusts are down instead of up. This support, as illustrated, carries a roll that contacts with the work, reducing friction between the two members and at the same time supporting the work directly under the point receiving the thrust of the cutter. When cutting internal gears that are not large enough in diameter to reach to the support in the apron, a special support, shown in the detail view in Fig. 2, is used. This support consists of a bracket fastened by screws to the apron and carries a roll that supports the work.

Ganging of Gear Blanks

Owing to the reciprocating action of the gear shaper, there is no necessity for ganging or grouping a large number of gear blanks on the work-arbor at one time. The excess travel of the cutter is only from 1/16 to 3/32 inch; consequently little time is gained in clamping a large number of blanks on the arbor at one time. As a matter of fact, greater refinement and accuracy can be obtained by holding only a few blanks at one time. The greatest production is obtained when the blank permits the stroke of the cutter to be from 2½ to 3 inches.

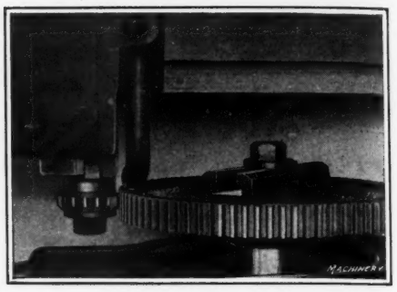


Fig. 6. Work-support mounted on Saddle—applied when Shape of Work will permit and when Cutter is operated on Pull Stroke

Two methods of holding gear blanks are shown in Fig. 7. The gear blanks shown at *A* are of the arm type and have a face ¾ inch wide. Four of these blanks are held on the arbor at one time, making a total travel of 3 inches. The work rests on a faceplate that supports it at the rim, and is clamped down by means of a top plate, against which the work-support carried on the saddle rests. This forms a compact and rigid method of holding this type of gear. The gear blanks shown at *B* have a larger hole; hence the faceplate is made with an extended shank or projection. This fits the holes in the gear blanks, and locates them centrally from the work-arbor. The top plate is also used for clamping the work down, as in the previous case, the work-support resting against it.

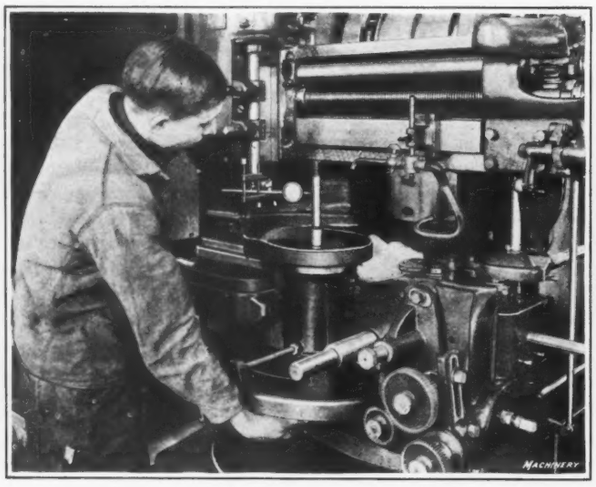


Fig. 3. Testing Truth of Work-arbor with a Dial Indicator

Fig. 4. Testing Concentricity of Circumference of Gear Blanks with Hole

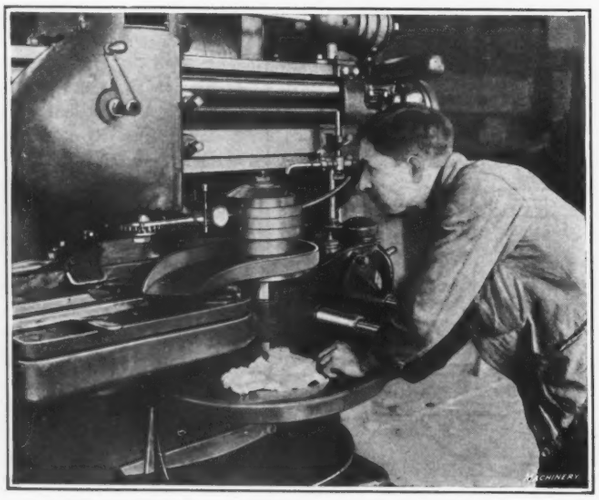


Fig. 5. Testing Truth of Gear Blanks after clamping on Work-arbor—This Test indicates if Faces are Square with Holes

One exception to the rule regarding ganging is shown in Fig. 8, where the parts being held are disks for a friction disk-plate clutch. Owing to the requirements of these disks, exceptional accuracy is not necessary; as a consequence, a large number can be held at one time. The best practice, however, is to limit the travel of the cutter to 3 inches, for then the gear shaper can be operated at its greatest efficiency. At *A*, in Fig. 8, is shown the type of work fixture used for holding disks when cutting teeth on the external diameter; and at *B* the type of fixture used for cutting smaller disks with the teeth on the internal diameter. It will be noticed that the work-arbor is used simply for locating the fixture centrally and for clamping it rigidly to the top face of the work-spindle. The disks are held in the internal fixture by means of a clamping ring that has elongated slots for the screws to facilitate removal. Holes are drilled, at an angle, from the fixture pocket out to the circumference to facilitate the removal of oil and chips. Owing to the small diameter of these internal disks, the hub type of gear-shaper cutter is used; this is threaded and held directly onto the cutter-spindle, no nut being used.

Method of Holding Typical Automobile Gears

The sliding type of automobile transmission gears are either provided with a splined hole or with a square hole. When they have a splined hole, the gear blanks can usually be held directly on the work-arbor, but when they have a square hole, it is better to use bushings with a square external surface

to fit the square hole in the gear and a round hole to fit the arbor. Fig. 9 shows two fixtures used for this purpose. At *A*, the hubs on the gear blanks extend past one end only; hence it is necessary to use a faceplate and a top plate cupped out to clear these projections. Bushings that are squared on the outside to fit the gear blanks and are round in the hole to fit the arbor are so made that one of the bushings extends through one gear and into the next, positively centering both gear blanks accurately with each other and with the arbor. The faceplate and top plate are made large enough so that they support the work as close as possible to the root diameter of the teeth in the gear blank.

At *B* is shown a fixture that differs slightly from that at *A*. The design of these gears is such that the hubs extend past both faces of the rims; so to get a rigid support it is necessary to provide a spacing plate of sufficient thickness to make up for the distance that the hubs extend past the faces of the rims. With this arrangement, it is obvious that the gear blanks are supported much more rigidly than they could otherwise be, and consequently can be cut more rapidly.

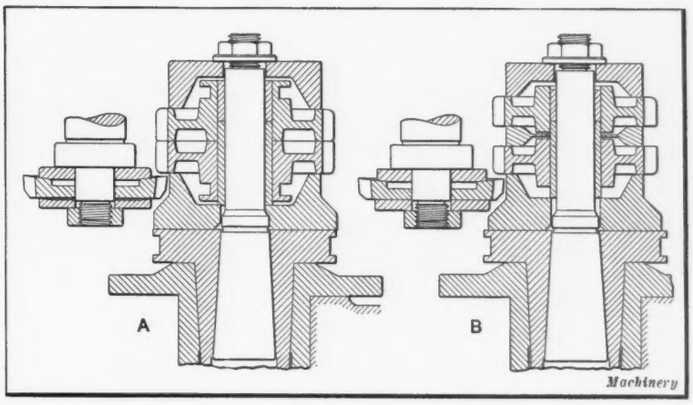


Fig. 9. Methods of holding Automobile Transmission Gears

Fixtures for Holding Shank Gears

As mentioned, shank gears can be held on the gear shaper by having the shank extend through the hole in the work-spindle and using a floating fixture or other means of clamping and supporting the work. Figs. 10, 11 and 12 show three interesting fixtures of this type. That shown in Fig. 10 was designed for holding the pinion shaft for a lathe. This shaft is of such diameter that the standard work-spindle cannot be used; hence it is necessary to use the largest work-spindle, which has a capacity of 5 inches in diameter. The fixture comprises two bushings *A* and *B*, which are inserted into the work-spindle and held in place by screws, as shown. The lower bushing *B* is supported by a lower plate *C*, which is fastened to the lower end of the work-spindle. Inserted in the bushings *A* and *B* are two additional bushings *D* and *E*, the former being split into two parts to facilitate removal of the work. The work, which has a shoulder on it, is clamped against bushing *E*, by means of a through bolt *F* and nuts *G* and *H;* nut *G* is pinned to the through bolt, but nut *H* is removable. With this work fixture, it is possible to support the work directly from those points on which it rotates when assembled in the machine in which it is to be used; consequently, the teeth in the blank can be cut concentric with the journals upon which the shaft rotates in the bearings.

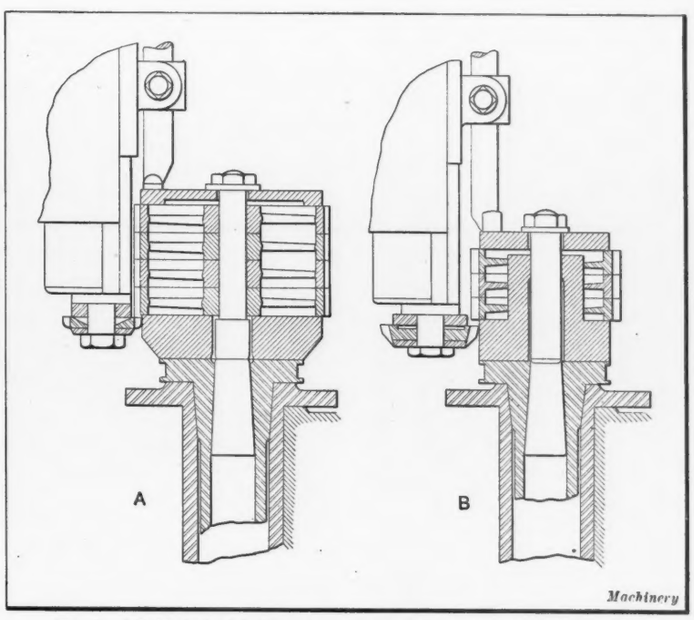


Fig. 7. (A) Method of holding Armed Gear Blanks. (B) Method of holding Automobile Timer Gears

A somewhat similar fixture is shown in Fig. 11. In this case the pinion blank is much shorter; consequently, a shorter bushing can be used. This fixture is fastened directly to the top face of the work-spindle and the bushing is made to fit the two bearing surfaces on the gear blank. The gear blank has a small shoulder which rests on a projection in the bushing. The blank is clamped directly into the bushing by means of a lower plate and a through clamping bolt, as illustrated. The through bolt is keyed to the lower plate to prevent its turning. The cutter is mounted so as to operate on the push instead of the pull stroke, because of the narrow recess in which the cutter must work. As far as the design of the fixture is concerned, however, the cutter could be made to work on either the pull or the push stroke. In Fig. 12 is shown a fixture of this type that was designed for cutting internal gears; the cutter in this case also operates on the push stroke.

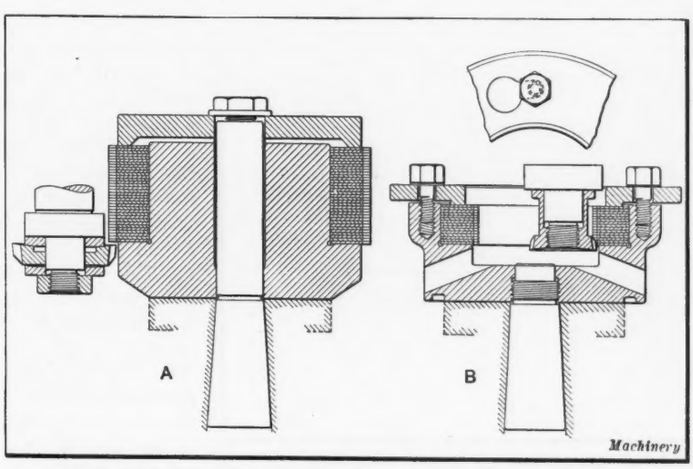
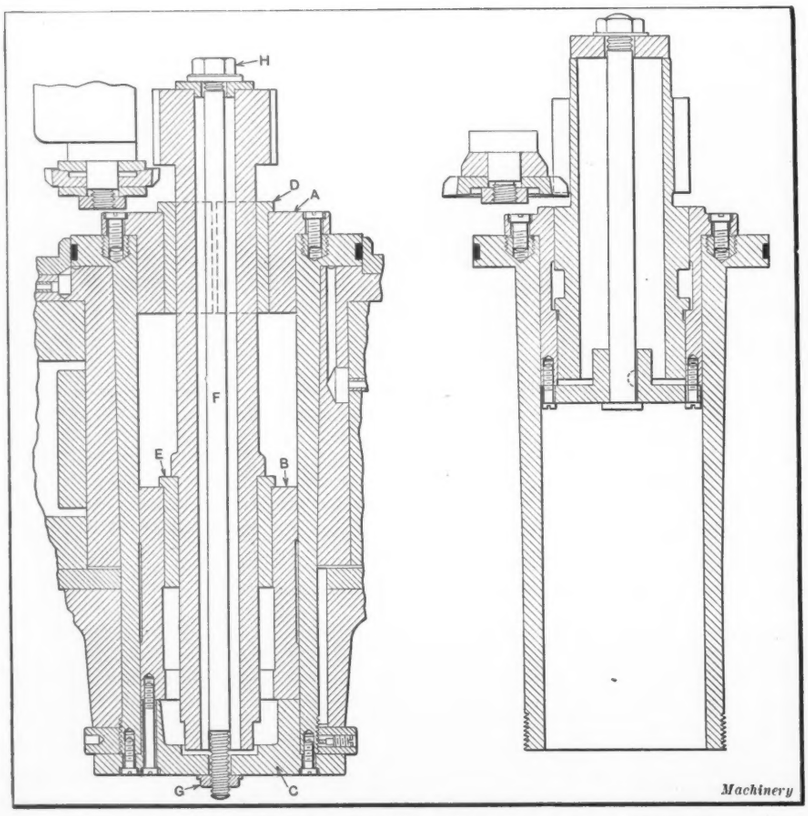


Fig. 8. Methods of holding Disks for Automobile Disk Plate Friction Clutches

Holding Shank Gears in Floating Fixtures

In the previous examples, the gear blanks were held in fixtures that located the work directly from the hole in the work-spindle. In Figs. 13 and 14 two fixtures are illustrated in which the floating principle is adopted. In the fixture shown in Fig. 13, the lower end of the work is guided by a taper bushing *A* fitted into the lower end of the work-spindle and the work is clamped and located by a floating fixture *B*, which is fastened by screws to the top face of the work-spindle. It carries a bushing that fits the shank of the gear, and the latter is clamped in the fixture by a headless screw and segment brass shoe. In setting up, this type of fixture is trued up before it is rigidly clamped to the work-spindle. The method used is to put the gear blank in the fixture and have it extend sufficiently above the bushing



Figs. 10 and 11. Fixtures for holding Large-shank Gears on No. 64 Gear Shaper

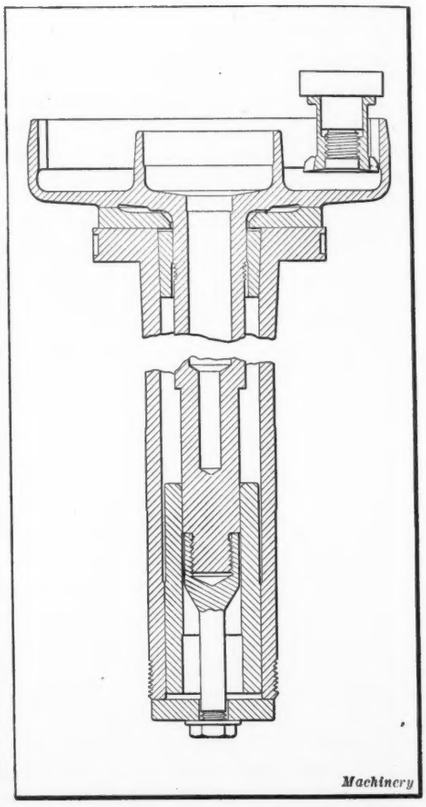


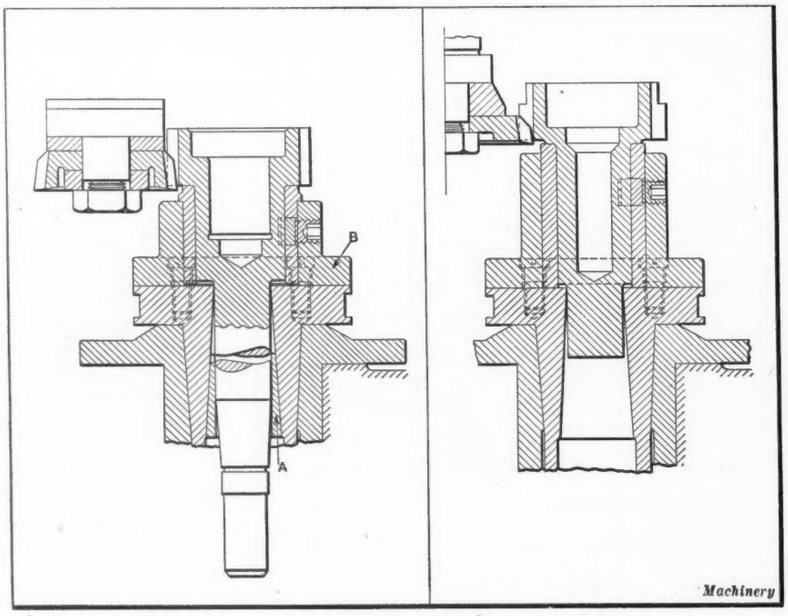
Fig. 12. Fixture for holding Internal Shank Gear

for the needle of an indicator to be brought to bear on it. The fixture is then shifted into a position where the bearing on the gear blank runs dead true, when it is clamped rigidly to the work-spindle and the gear blank is pushed down into place and clamped. By following this procedure, the pitch circle of the teeth will be concentric with the bearing from which the pinion shaft is located when in use. In this particular case, the pinion is provided with helical teeth and the helical gear-shaper cutter is used, operating on the push stroke.

In the fixture shown in Fig. 14, the gear blank has a much shorter shank; hence it does not require an additional support or guide in the work-spindle. The floating fixture, as before, is fastened directly to the top face of the work-spindle and carries a bushing for centering the work. This fixture is trued up in the manner just described.

Special Work-arbor Support

In cases when a long work-arbor is necessary, or the work has an extended shank that, owing to the design of the gear and the point where the teeth are to be cut, cannot be so located as to pass through the work-spindle, it is necessary to provide a work-arbor support. A case in point is the oil-pump drive shaft for an aeroplane motor, shown in Fig. 15. In this case, a helical gear is to be cut in the rear of a bevel gear, and extending out from this is a long shank. This particular gear represents a difficult holding proposition, so the special fixture illustrated was designed. The work-arbor is provided with a very short projection, which is made to fit a special faceplate that it centers and that is clamped to the top of the work-spindle. This faceplate also centers the lower end of the drive shaft. The work is clamped to the faceplate by means of a through bolt and plate, as illustrated, the through bolt being keyed to the faceplate to prevent its rotation, and provided with a head to prevent its being pulled out of the faceplate. At the upper end, the drive shaft is supported in a bushing, which is retained in a special bracket *A*. This bracket, in turn, is held on a large stud *B*, which passes down through the special support, and is located at the rear end by means of another stud *C* centered by a bushing. The lower end of the large stud is provided with annular gear teeth in which pinion *D* meshes. This pinion, as shown in Fig. 16, extends out from the special bracket and is squared on the end to fit a crank-handle. By placing a crank-handle on the squared end of the pinion-stud, the large supporting stud *B* can be raised or lowered so as to move the top bracket *A* from the work. A screw *E* is also provided for clamping the elevating stud to increase the rigidity of the fixture. The bracket itself is so



Figs. 13 and 14. Floating Type of Fixtures used for holding Gears with Extended Shank

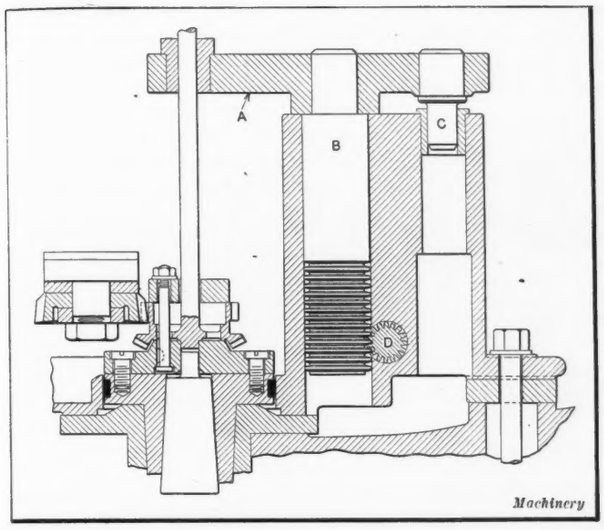


Fig. 15. Special Work-arbor Support for Extra-long Arbors and Shank Gears

made that it forms the cover *F* for the apron; it is clamped also to the apron by a through bolt passing through the hole ordinarily occupied by the support in the apron (see Fig. 2).

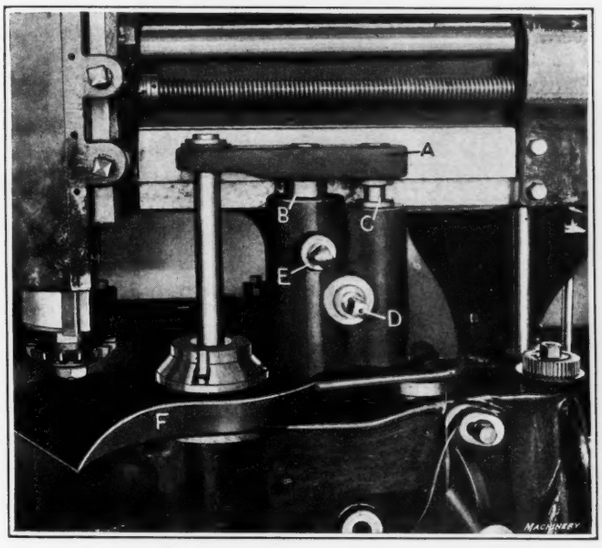


Fig. 16. Method of mounting Special Work-arbor Support

A fixture constructed along similar lines is illustrated in Fig. 17. In this case, the fixture is used for holding a cluster countershaft gear. The hole in the lower end of the countershaft gear fits over a special work-arbor, which is clamped directly to a plate fastened to the top face of the work-spindle, the bolts passing through the holes in the flange of the gear. At the upper end it is supported in a bushing in the special type of work-support. In cutting this particular gear, the two lower gears are cut with the cutter operating on the push stroke, and the upper gear with the cutter operating on the pull stroke.

Still another fixture of this type is shown in Fig. 19; this is used for holding a herringbone reduction pinion that has an extended shank on both ends. One shank passes down through the hole in the work-spindle, whereas the other shank extends up through the special support. The lower end is supported by a fixture, which carries a locating finger that holds the blank in the proper relation to the cutter, so that the teeth will match. The shoulder of the gear rests on the top face of the work-spindle and is held down by a clamping collar and screw from the lower end, the lower shank being provided with a tapped hole.

Fixture for Holding a Large Internal Gear Ring

Fig. 20 illustrates a fixture used for holding a large internal gear ring. This fixture is made with a hub in the center in the form of a wheel, and is held centrally by means of the work-arbor. It is provided with a machined shoulder, which locates the ring centrally and against which the work is clamped by means of toe clamps, as illustrated. This is a very simple fixture and is easily and quickly operated. Of course, it is necessary on work of this kind to open the apron in order to remove the work from the fixture.

Still another method of holding an internal gear is shown in Fig. 21. In this case, no fixture except the regular work-arbor is necessary. The gear blank being held is a combined internal and external helical gear, and is supported at the rim by means of the support held in the apron. Owing to the small diameter of the internal gear, the regular roll support cannot be employed; hence a disk made eccentric with the shank so as to reach over far enough to support the work is

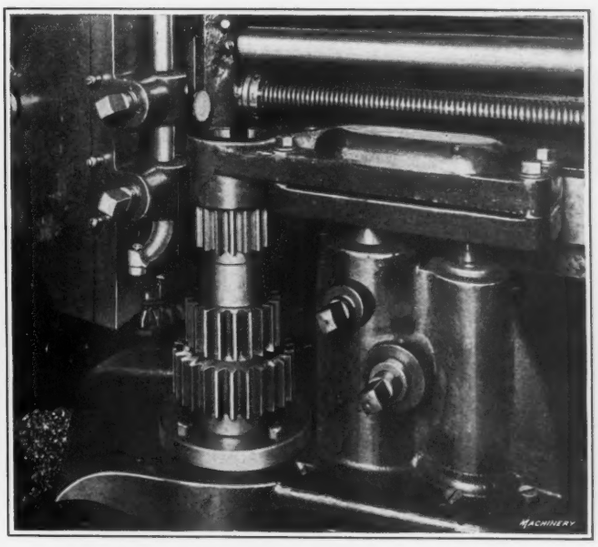


Fig. 17. Special Fixture for supporting Cluster Gear

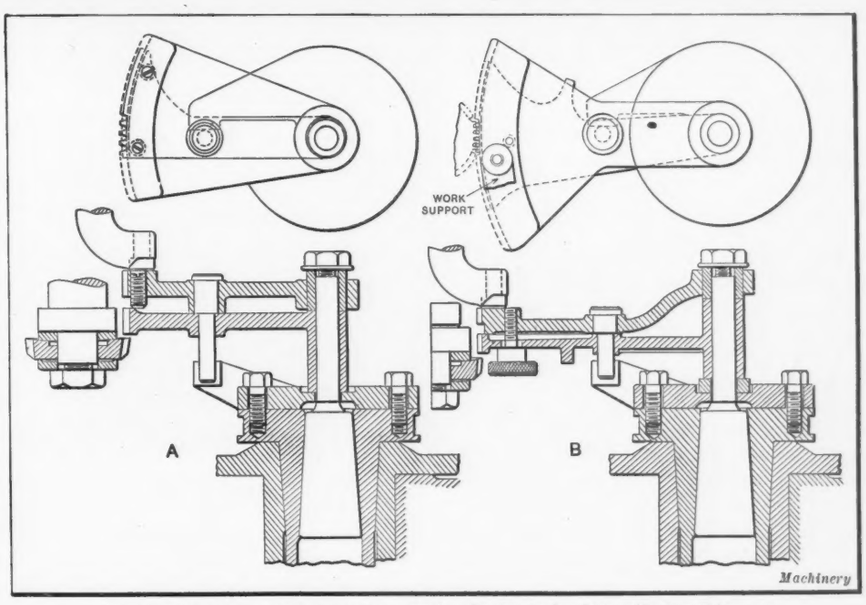


Fig. 18. Two Types of Fixtures for supporting Quadrants for Automatic Saw Trimmers

used. The cutter is operated on the push stroke and the thrust is taken directly on the support in the apron. Owing to the fact that when cutting an internal gear an intermediate gear is introduced into the change-gear mechanism, the greatest production can be obtained by cutting the internal and external gears in separate settings.

Simple Fixture for Holding a Cam

A simple type of floating fixture used for holding a motion-picture cam is illustrated in Fig. 22. The fixture is so made that it is fastened directly by screws to the top face of the work-spindle, and is split for clamping the special arbor on which the work is held by means of a nut. The irregular outline on this cam must bear a certain relation to one of the three holes in the cam, so a pin is driven into the fixture to fit one of these holes, and thus locate the work in the correct position. The cutter also must start to operate at a certain point on the work; the simplest way to do this is to set the cutter to a master cam. Change-gears are selected so that the work makes two revolutions to one revolution of the cutter. The cutter is made twice as large as the blank being cut and one-half revolution of the cutter completes one cam.

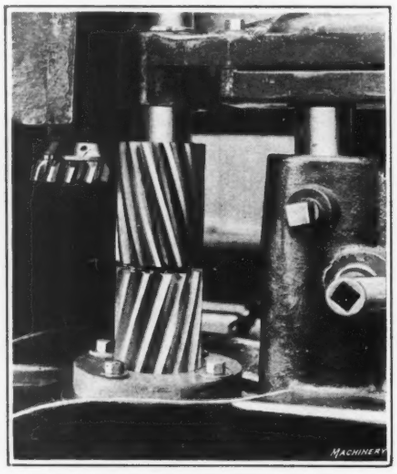


Fig. 19. Special Fixture for supporting Herringbone Reduction Pinion

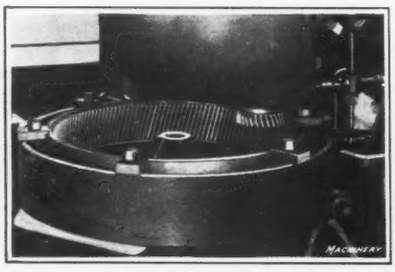


Fig. 20. Fixture for holding Large Internal Gear Ring

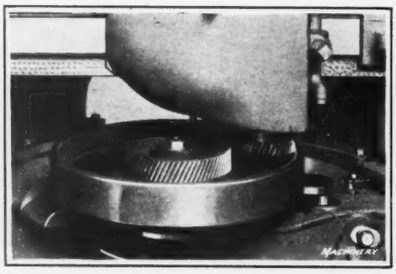


Fig. 21. Method of holding Internal and External Helical Gear Blank

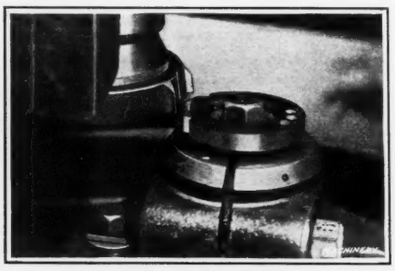


Fig. 22. Simple Type of Floating Fixture for holding Cam

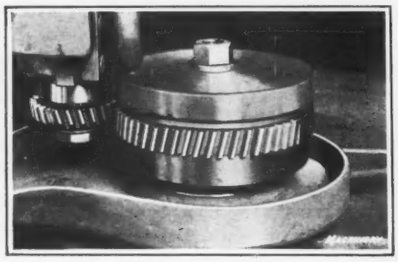


Fig. 23. First Setting on Herringbone Gear Blank

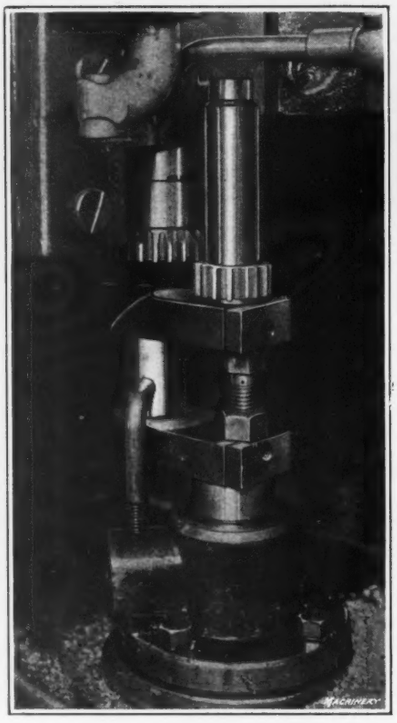


Fig. 24. Method of supporting Single-throw Crankshaft

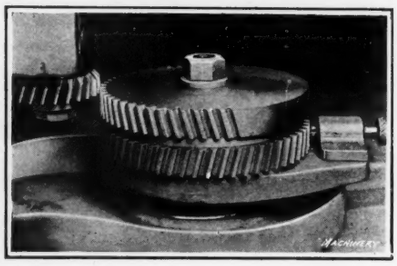


Fig. 25. Second Setting on Herringbone Gear Blank

Method of Holding Herringbone Gear Blanks

Figs. 23 and 25 show how herringbone gear blanks are cut on the gear shaper. The first operation, which is illustrated in Fig. 23, is a simple one; it consists simply in locating the gear blank on a faceplate and clamping it down by means of the nut on the arbor. The work-support held on the saddle is then brought to bear on the top face of the gear blank to provide additional support. The helical cutter is operated on the pull stroke working into the recess.

For the second operation, it is necessary to use a locating fixture. As shown in Fig. 25, this consists of a special faceplate having a boss fastened to it in which a locating pin is held. This pin is beveled to fit in the tooth space in the gear previously cut, and thus accurately centers it with the cutter. The method of locating the herringbone gear in which the teeth are not staggered is done in two ways. When a master gear is available, the cutter can be set to this, but when not, the cutter must be rotated by hand and lined up with the lower points of the teeth in the gear previously cut.

Holding Odd-shaped Work on Gear Shaper

The work shown in Fig. 18 is a quadrant for an automatic saw trimmer. It has a boss with a hole through it and the teeth are cut at the rim of the segment. The fixture used comprises the regular work-arbor, which is made to fit the hole in the boss and is long enough to carry a special supporting fan-shaped bracket. This bracket is placed on top of the quadrant being operated on, and is held by the regular arbor-nut. On the outer end, near the rim, it carries two headless screws, which are brought to bear against the top face of the rim of the quadrant. It also carries a stud, which is used for locating the quadrant in the correct relation to the cutter. In order to preserve this relation, a special faceplate is used; this has an extended boss against which this locating stop is brought to bear. The cutter is operated on the pull stroke, and the thrust is taken directly by the work-support held on the saddle, which rests on the top of the quadrant support.

A somewhat similar fixture is illustrated at *B*, Fig. 18. In this case, however, the headless screws are dispensed with and a clamping screw binds the top supporting plate to the work.

The fixture shown in Fig. 24 was not made especially for the work in hand but was rigged up to handle a comparatively small number of parts. The work is a single-throw crankshaft on which an external gear is to be cut close up to the cheek of the crank. The fixture is of the floating type with a hole through it to fit the shank of the crankshaft. A stop locates the gear teeth in the correct relation with the crankpin. The cheeks of the crankshaft are prevented from collapsing by a nut and screw.

PRODUCTION OF METAL FURNITURE

PLANNING, ESTIMATING, DESIGNING, CHECKING AND MANUFACTURING

BY K. GEORGE SELANDER [1]

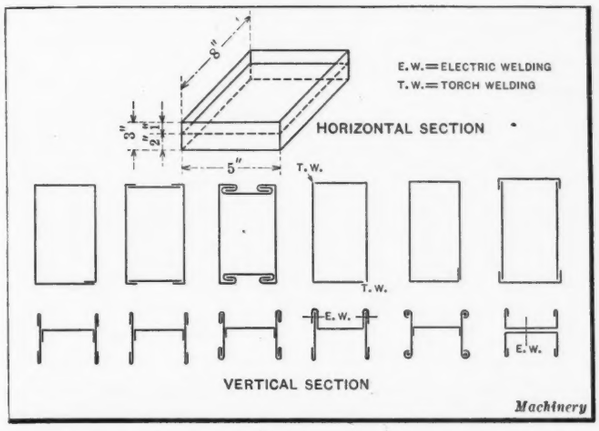


Fig. 1. Display Tray for Department Store, which illustrates Principles in Metal Furniture Design

LITTLE has been written of the actual process of making metal furniture. Though some parts of the work, such as welding, estimating, bending allowances, designing forming tools, etc., have been described by various writers, the real process of development of a piece of furniture has not been described. According to its use, metal furniture may be divided into ten classes: bank equipment, library equipment; office equipment, which may be subdivided into the American and the European systems; ship furniture; equipment for the government, such as post-office boxes, shelving and bag racks, court-house equipment, etc.; telegraph and fire-alarm equipment; interior of railroad cars and automobile bodies; factory equipment; household equipment, such as chairs, kitchen cabinets, etc.; and miscellaneous equipment, which includes articles often made of wood or other material that can be made at a profit from sheet steel. According to

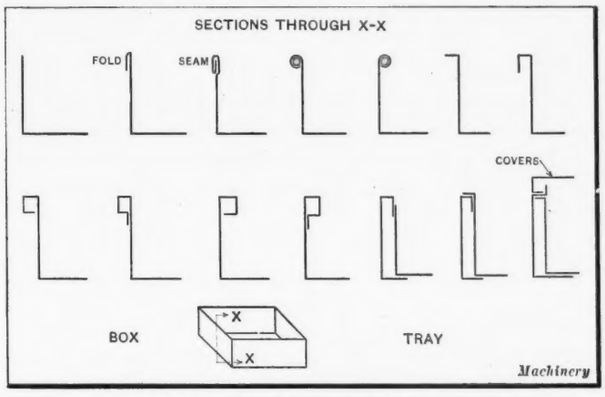


Fig. 2. Vertical Sections through Boxes of Similar Construction, showing Variations in Design

its process of manufacture, metal furniture may be divided into two classes, built-to-order and stock work. At first, only built-to-order furniture was made, but the tendency has been to produce stock work to a greater and greater extent during the past eight years, so that some firms are now specializing in this work and a few are making a specialty of certain classes of furniture, such as office filing devices, desks, safes, etc. Considering the breadth of the field, it is surprising that so few engineers and draftsmen have shown interest in metal-furniture manufacture.

The manufacturing process consists of six steps: planning, estimating, engineering, manufacturing, shipping and erecting. Planning or analyzing the work requires a thorough knowledge of construction combined with inventive ability. The man doing this work must know the various shapes and bends and their names. In all cases, he must know the finished product that is to be made, its purpose, way in which it will be used, construction, gage of the metal, quantity to be manufactured and tools required. The method followed is best shown by an example, for the same general principles govern all cases. Suppose that it is required to make a box or tray, as shown in Fig. 1, 8 inches long, 5 inches wide and 3 inches high, which is to be used in a large department store for the storage and display of small articles. It is to have a division 1 inch from the top and 2 inches from the bottom, so that it may be inverted and the deeper side used. Six methods of making this box are shown here, but many more could be devised. Fig. 2 shows vertical sections through boxes of similar construction; Fig. 3 is a horizontal section through the uprights, showing bends and forms used for this purpose; and Fig. 4 is a vertical section through the shelves or tops, showing bends and forms that may be used. The construction method will depend first on the tool equipment of the factory and then on the amount of material and labor required. After the construction method is determined upon, it is necessary to decide the cutting size of the piece, or size of blank that will be required, also what notching, bending, seaming, drilling, filing and welding must be done.

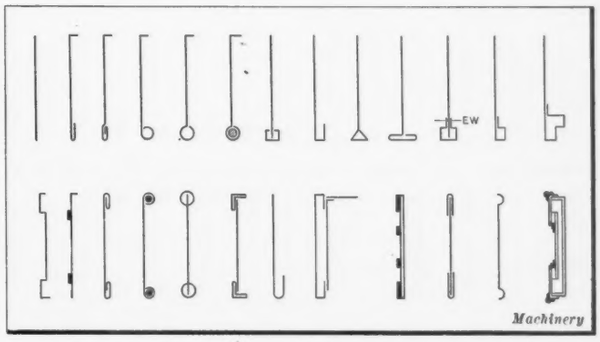


Fig. 3. Horizontal Cross-sectional Views through Uprights

When the planning is completed it is necessary to estimate the labor and material required. To the actual cost of these must be added a certain percentage for overhead expenses. It makes considerable difference in the cost of an article whether it is made in lots of ten, fifty, one hundred, or one thousand.

Engineering Department

The duties of the engineering department are many and varied on account of the many types of cases and requirements. Standardization of construction has lately been adopted by many concerns; but this is a slow process on account of the alteration or betterment of construction that is continuously being made in order to reduce the cost of production.

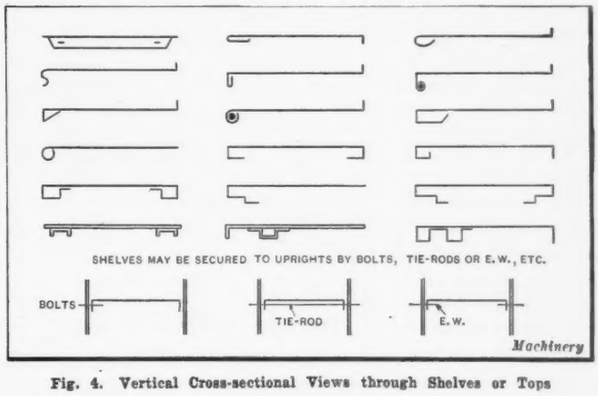


Fig. 4. Vertical Cross-sectional Views through Shelves or Tops

[1]Address: O. M. Edwards Co., Syracuse, N. Y.

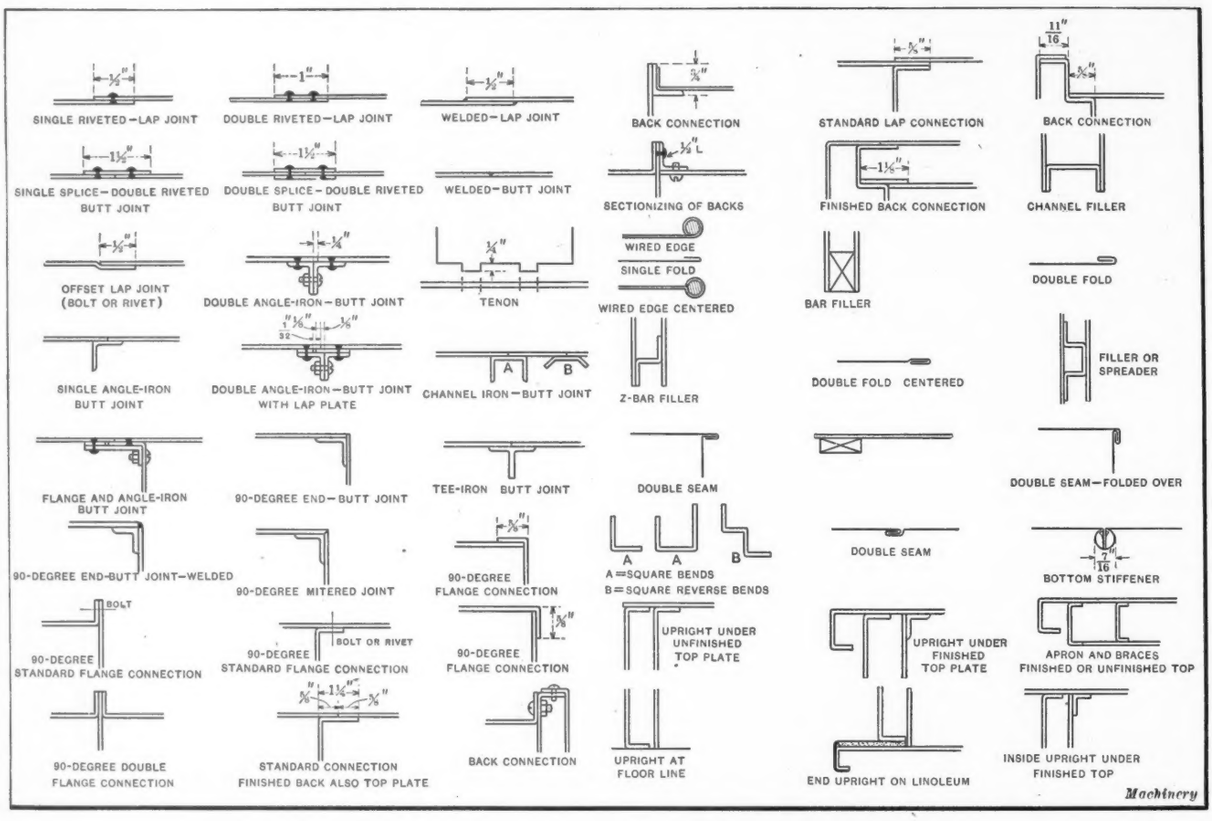


Fig. 5. Commonly used Forms of Construction in Sheet Metal Furniture Manufacture

A first-class drafting or engineering department should be divided into the following sections: submission drawing, contract drawing, and stock drawing. The submission drawing consists generally of a front and an end elevation, with the necessary over-all dimensions and schedule of devices, that is, the number of drawers, files, shelves, roller shelves, etc., that the article may contain. No construction is shown nor are sections made until the contract is received, for this would increase the cost of this work and at the same time show the construction methods to competitors. This section of the engineering department should be equipped with cuts of moldings, samples of castings, marbles and catalogues of metal fixtures made by other manufacturers. After they have been used, the drawings should be indexed and filed for future reference. All mail inquiries, providing a drawing is required, should be submitted to this department. It is quite necessary for this department to have all its information in such shape and form that drawings can be made up quickly and accurately.

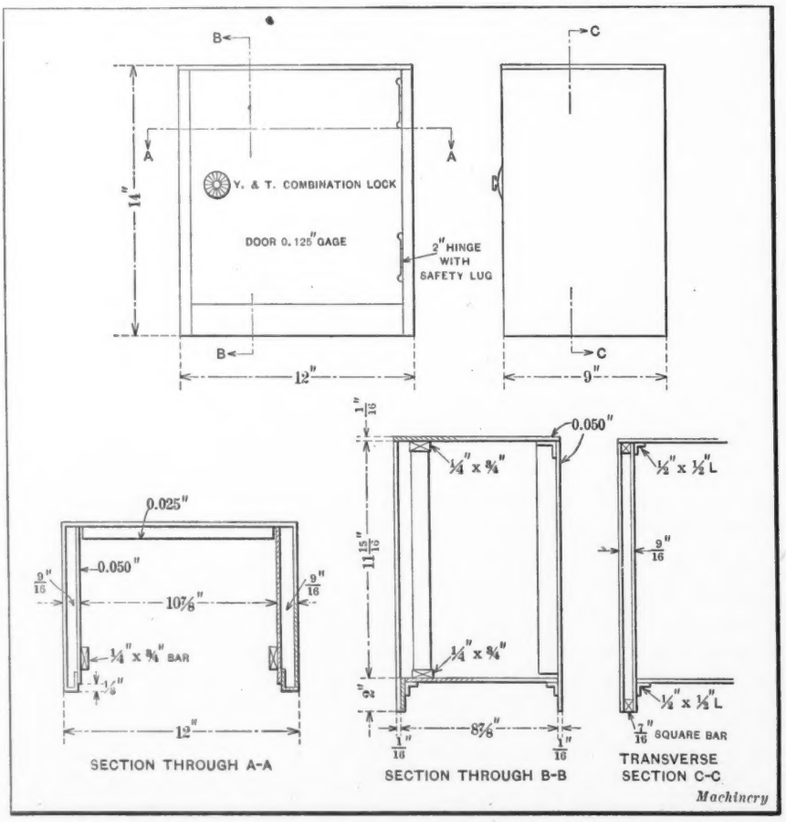


Fig. 6. Sheet Metal Safe, 14 by 12 by 9 Inches, equipped with Yale & Towne Combination Lock

The contract drawing is a submission drawing on which proper horizontal and vertical sections have been worked out, full size, if necessary; this drawing should specify the stock parts used and give the numbers of hardware parts, etc. The making of these drawings is the most interesting of all the work in the engineering department. A metal-furniture draftsman should compile a book of constructions and methods. Fig. 5 shows constructions generally used and Fig. 7 illustrates the various pipe connections and how they may be employed. The electric-welding process has revolutionized the metal-furniture industry by reducing the amount of labor necessary. Thousands of rivets were used a few years ago, whereas now spot welding is generally employed wherever possible. The field is open to the inventor, and many things never made of metal are constantly being produced. A study of the catalogues of steel-furniture manufacturers will give a fair knowledge of what is now being made. The stock drawing is a more finished drawing and gives all information,

showing all bent uprights in flat, lay-out of holes, notches, cut-outs, etc. In other words, it should comprise a complete factory drawing.

Detailing or Listing

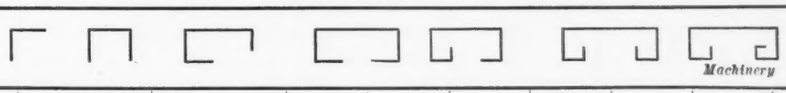
After the factory drawing has been made, with all its sections and dimensions, it is transferred to the detailer or the man who makes out the listing of material. It is strange, but there are few men who are able to make a complete finished drawing and also list the material correctly. The only reason for this is that it involves good memory, a system, and a knowledge of construction; the lack of handbooks giving the necessary information makes the work more difficult. The best men in this branch today are men who have worked up from the ranks; these men are actually the constructors and developers of the present construction in filing devices. Listing is very interesting, as it involves an all-around knowledge of the trade.

Until the adoption of definite allowances for bends, which were published in MACHINERY in 1911 and 1915, each foreman was the ruling power in his department, and all the young engineer or draftsman could say was, "O, yes; I see," although he never did. As it would greatly increase the expense if the manufacturer had to have a complete mechanical drawing made of each case, it has been left to the listers of materials, who generally are practical men, to check up the construction as to practicability, etc. Convenient tables should be provided to facilitate the work and relieve the men of strain. Among the tables and charts that will be found useful by listers are the allowances for square bends, which are given in Table 1; list of stock parts used by the manufacturer, such as hinges and hardware in general; chart showing the general construction, bends and flanges, as given in Fig. 5; chart of irregular bends produced by specially made dies; cutting or blank allowances; tables of screws and rivets; table of standard gages and weights of steel; table of allowances for pins, studs, wheels, etc.; and table of drills to be used. Many draftsmen specify material made of stock that is not available. When using the allowances for square bends given in Table 1, fractions like 17/64 and 25/64 should be reduced to 1/4 and 3/8, etc. A simple rule where absolute accuracy is not required is to take off 1/8 inch for single bends of 18-, 16- or 14-gage material, 3/16 inch for one or two bends of 13-gage stock, and 1/4 inch for one or two bends of 12-, 11- or 10-gage material. In all other cases, the table should be used.

Fig. 6 shows a factory drawing. It is necessary for the lister, or the man who makes out the bill of material, to know how the lock is fastened on; whether the lock is fastened to the door direct or if a lock block or bar must be supplied; if the hinges are made with a straight or bent leaf; if the top plate is fastened on with rivets, screws, or by welding; the cutting size of the outside shell or jacket, which is 0.050 U. S. standard gage; and if the case is to be assembled before finishing. As insignificant as these questions may seem to be, they must be answered, for the man at the bench, or the actual builder, must know these facts. A correct way of listing the material is to follow a certain rule and not jump from one item to another, which leads to many omissions. A good rule is to list all vertical plates first, such as ends, inside ends and inside upright fillers; second, all horizontal plates, such as tops, shelves, drawer strikes, bars, etc.; third, stock parts used; fourth, all wrought material, such as angle bars, etc.; fifth, hardware. Manufacturers usually provide printed sets of listing sheets, each sheet in the set containing only the information that is required by the department to which it is sent.

The checking chart shown in Fig. 8, which has been developed by the writer, will be found handy by metal-furniture draftsmen. One of the greatest troubles of the metal-furniture manufacturers today is to obtain correct measurement and field data from inexperienced salesmen. Memoranda charts of the kind shown in Fig. 9 will be useful for remedying this trouble. The table of fractions given in Table 2 will also facilitate more accurate additions, as common fractions are used almost entirely on factory drawings. In order to cut costs to a minimum, it is important that all available shortcuts and tables be used. Long rules and circular letters disturb the regular routine, and in many instances actually prevent speed. It takes special training and experience to be a first-class lister and do it right, as a few "misses" in dimensions and errors in figuring of bends will cost the manufacturer a good deal of money. The work is pleasant if a person becomes acquainted with all the "in's and out's" in the trade. Too many rules and tables are confusing to some men; therefore a proper analysis of what is needed will materially assist the lister in getting out the work required quickly, neatly and accurately.

TABLE 1. ALLOWANCE FOR SQUARE BENDS IN INCHES (FRACTIONS AND DECIMAL EQUIVALENTS)



Wt. Sq. Ft. Ounces	Wt. Sq. Ft. Pounds	Gage	Frac.	Decimal	1 Bend	2 Bends	3 Bends	4 Bends	5 Bends	6 Bends	7 Bends
32	2.000	18	1/20	0.0500	5/64 = 0.0840	5/32 = 0.1680	1/4 = 0.2520	11/32 = 0.3360	13/64 = 0.4200	1/2 = 0.5040	15/32 = 0.5880
40	2.500	16	1/16	0.0625	3/4 = 0.1042	13/64 = 0.2084	5/16 = 0.3126	27/64 = 0.4168	33/64 = 0.5210	3/8 = 0.6250	29/64 = 0.7294
50	3.125	14	5/64	0.0781	1/8 = 0.1300	17/64 = 0.2600	25/64 = 0.3900	33/64 = 0.5200	21/32 = 0.6500	25/32 = 0.7800	29/32 = 0.9100
60	3.750	13	3/32	0.0937	5/32 = 0.1562	5/16 = 0.3125	15/32 = 0.4688	5/8 = 0.6250	25/32 = 0.7813	15/16 = 0.9375	1 3/32 = 1.0937
70	4.375	12	7/64	0.1094	11/64 = 0.1823	23/64 = 0.3646	35/64 = 0.5469	47/64 = 0.7292	29/32 = 0.9115	1 3/32 = 1.0938	1 17/64 = 1.2670
80	5.000	11	1/8	0.1250	13/64 = 0.2083	27/64 = 0.4167	9/16 = 0.6250	53/64 = 0.8333	1 1/32 = 1.0417	1 1/4 = 1.2500	1 23/64 = 1.4560
90	5.625	10	9/64	0.1406	15/64 = 0.2344	15/32 = 0.4688	45/64 = 0.7031	15/16 = 0.9375	1 11/64 = 1.1720	1 13/32 = 1.4063	1 5/8 = 1.6400

In using the table it would be advisable to change fractions such as 17/64 to 1/4, 25/64 to 3/8, and so on. For single bends in 18-, 16- and 14-gage stock, the rule is take off 1/8 inch; for 13-gage, 1 or 2 bends, 3/16 inch; and for 1 or 2 bends in 12-, 11- and 10-gage, 1/4 inch. For more than 1 or 2 bends where work does not have to be held to absolutely correct measurement, the above rule may be used, but where correct measurements are required, use the table.

TABLE 2. ADDITION OF 32NDS AND 16THS

32nds		10	20	30	40	50	60	70	80	90	100	16ths		10	20	30	40	50	60	70	80	90	100
..	..	5/16	5/8	15/16	1 1/4	1 9/16	1 7/8	2 3/16	2 1/2	2 13/16	3 1/8	..	..	5/8	1 1/4	1 7/8	2 1/2	3 1/8	3 3/4	4 3/8	5	5 5/8	6 1/4
1	1/32	11/32	21/32	31/32	1 9/32	1 17/32	1 25/32	2 7/32	2 17/32	2 25/32	3 5/32	1	1/16	1 1/16	1 5/16	1 15/16	2 5/16	3 1/16	3 11/16	4 7/16	5 1/16	5 11/16	6 5/16
2	1/16	3/8	11/16	1	1 5/16	1 5/8	1 15/16	2 1/4	2 9/16	2 7/8	3 3/16	2	1/8	3/4	1 3/8	2	2 5/8	3 1/4	3 7/8	4 1/2	5 1/8	5 3/4	6 3/8
3	3/32	13/32	23/32	1 1/32	1 11/32	1 21/32	1 31/32	2 9/32	2 19/32	2 29/32	3 7/32	3	3/16	1 3/16	1 7/16	2 1/16	2 11/16	3 5/16	3 15/16	4 9/16	5 3/16	5 13/16	6 7/16
4	1/8	7/16	3/4	1 1/16	1 3/8	1 11/16	2	2 5/16	2 5/8	2 15/16	3 1/4	4	1/4	1/2	1 1/2	2 1/4	3	3 3/4	4	4 5/8	5 1/4	5 7/8	6 1/2
5	5/32	15/32	25/32	1 3/32	1 13/32	1 23/32	2 1/32	2 11/32	2 21/32	2 31/32	3 9/32	5	5/16	5/8	1 9/16	2 3/16	2 13/16	3 7/16	4 1/16	4 11/16	5 5/16	5 15/16	6 9/16
6	3/16	9/16	13/16	1 5/16	1 7/16	1 13/16	2 3/16	2 9/16	2 15/16	3 5/16	3 11/16	6	3/8	3/4	1 7/8	2 5/8	3 1/2	4 1/8	4 3/4	5 3/8	6	6 5/8	7 1/4
7	7/32	17/32	27/32	1 7/32	1 15/32	1 25/32	2 3/32	2 13/32	2 23/32	3 7/32	3 15/32	7	7/16	1 1/16	1 11/16	2 5/16	2 15/16	3 9/16	4 1/8	4 13/16	5 7/16	6 1/16	6 11/16
8	1/4	9/16	7/8	1 3/16	1 1/2	1 13/16	2 1/8	2 7/16	2 3/4	3 1/16	3 3/8	8	1/2	1 1/8	1 3/4	2 3/8	3	3 5/8	4 1/4	4 7/8	5 1/2	6 1/8	6 3/4
9	9/32	19/32	29/32	1 7/32	1 17/32	1 27/32	2 5/32	2 15/32	2 25/32	3 5/32	3 13/32	9	9/16	1 1/16	1 11/16	2 7/16	3 1/16	3 11/16	4 5/16	4 15/16	5 5/16	6 9/16	6 13/16

Machinery

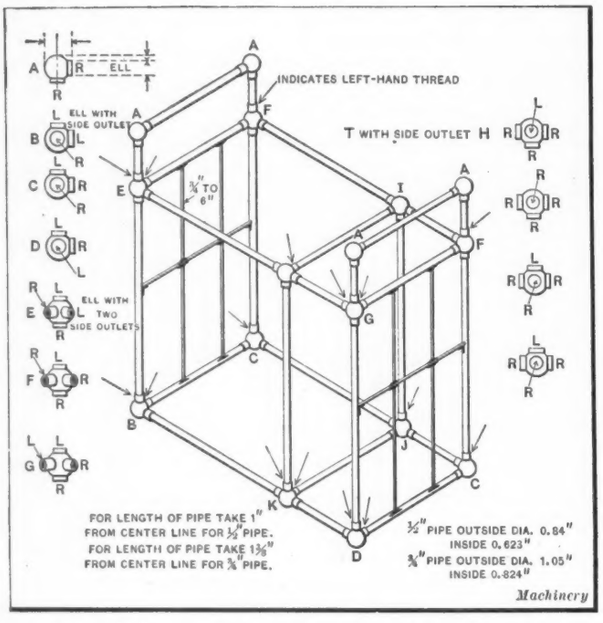

INDICATES LEFT-HAND THREAD
T WITH SIDE OUTLET
ELL WITH SIDE OUTLET
ELL WITH TWO SIDE OUTLETS
¼" TO 6"
FOR LENGTH OF PIPE TAKE 1" FROM CENTER LINE FOR ½" PIPE.
FOR LENGTH OF PIPE TAKE 1⅜" FROM CENTER LINE FOR ¾" PIPE.
½" PIPE OUTSIDE DIA. 0.84" INSIDE 0.623"
¾" PIPE OUTSIDE DIA. 1.05" INSIDE 0.824"
Machinery

Fig. 7. Various Forms of Pipe Connections and how they are used

Manufacturing Process

So many manufacturing methods are employed that it is impossible to state which is preferable, but the methods given here are those used by the largest manufacturers. The metal used may vary in thickness, but that from 1/4 inch to No. 30 gage is the most satisfactory. The sheets vary also in length and width; the usual limit, however, is 44 inches wide and 120 inches long, but wider and longer stock may be manufactured when desired. After the sheets are cut to size, they pass from the cutting department to the rolling, or straightening, department, where they are passed through the hammer block or rolling machine. If this process is omitted, the finished plates will have a most unsatisfactory appearance. The plates are then passed to the lay-out department, where they are squared and measured, and the positions of bends, notches, holes, etc., indicated upon them. The bends are marked with chalk directly on the plate or on a special paper blank that accompanies the work when it is sent to the next department. In the press room the plates are divided into classes, so that it will not be necessary to change the dies or machines too often. After all the necessary machining has been done, the plates are sent to the bench department, where they are fitted together according to the factory drawing. Here the work is assembled in the raw state and then taken apart so that the pieces may go to the finishing department.

When the work arrives in this department, the steel is first washed with benzine in order to remove all grease and oil, for the enamel will peel off if the steel is not properly cleaned before being given the desired enamel finish. To the writer's knowledge, no special cleaning apparatus has yet been designed, but it will probably be worked out eventually. After the plates are cleaned and dried, they receive the first coat of enamel, either by dipping them into troughs or by spraying. They are then placed in the baking oven, where they are heated to from 150 to 300 degrees F., the various colors requiring different temperatures. Several coats of enamel may be given, but the plates must be baked after each coat. Solid colors of various kinds are generally used, two coats being the maximum. When baked, the plates are water- or oil-rubbed, either by hand or by machine, and are then filled, sprayed and again baked. All imitations of wood are generally made by hand, although transfers are used. Steel plates have been finished in circassian walnut that have looked so natural that an expert would have difficulty in telling that they were imitations. Oak and Indiana walnut are difficult to imitate. After the work is entirely finished by the japanning department, it is delivered to the general assembling department for reassembling, if necessary; locks, hardware, etc., are then put in place, after which the work is checked up with the blueprint and prepared for shipment.

CHECK FROM LEFT TO RIGHT IN ORDER AS GIVEN		
JOB NO. OR CONTRACT	HOW TO SHIP	SET UP OR K.D.
COLOR OR FINISH	EXTERIOR INTERIOR	
FINISH HARDWARE		BRASS OR BRONZE
NUMBERS	NAME PLATES	TRANSFER
FRONT ELEVATION	TOP	LINOLEUM
CORNICE	PROPERLY SECTIONIZED	
LABEL HOLDER	PULLS, HANDLES, RODS	
BASE		
SCHEDULE OF DEVICES	DRAWERS, ETC.	WIDTH
HORIZONTAL SECTION		CHECK OVER ALL
END FILLERS		DETACHABLE
INTERMEDIATE SECTION	SECTION NUMBERS	REINFORCEMENT
BACKS		SECTION BACKS
VERTICAL SECTION		
TOP FILLER	ANY FASTENING TO WALL	BY MEANS OF
INTERMEDIATE SECTION		CHECK OVER ALL
BASE		
SCHEDULE OF DEVICES	REINFORCEMENT	HEIGHT AND DEPTH
MATERIAL	BOUGHT OUTSIDE	
CASTINGS	BRASS, BRONZE, GRAY IRON	MALLEABLE
LOCKS, KEYS	DIFFERENT, ALIKE	MASTERKEYED
FLAT KEY	PARACENTRIC KEY	
SPECIAL SUPPLIES		
STOCK ORDER	SHIPPED IN ADVANCE	
		Machinery

Fig. 8. Checking Chart developed to facilitate Work and eliminate Errors

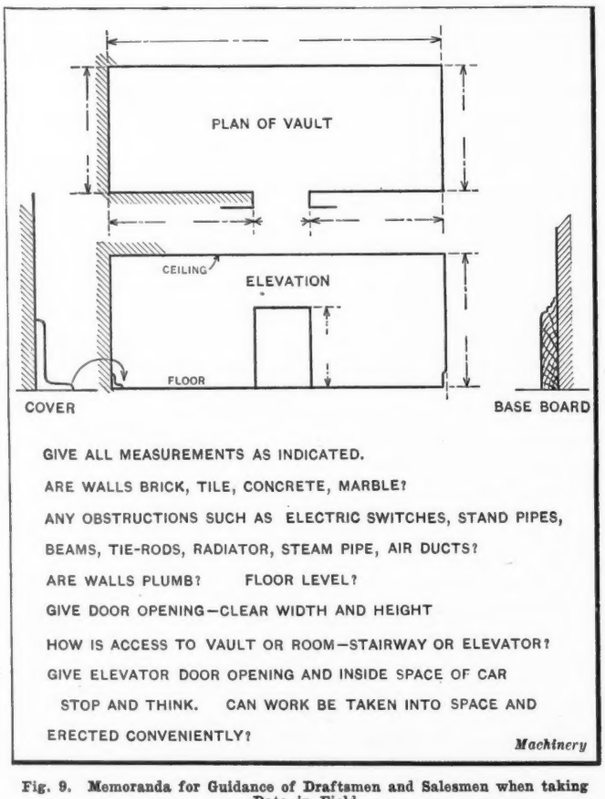

PLAN OF VAULT
CEILING
ELEVATION
FLOOR
COVER
BASE BOARD
GIVE ALL MEASUREMENTS AS INDICATED.
ARE WALLS BRICK, TILE, CONCRETE, MARBLE?
ANY OBSTRUCTIONS SUCH AS ELECTRIC SWITCHES, STAND PIPES, BEAMS, TIE-RODS, RADIATOR, STEAM PIPE, AIR DUCTS?
ARE WALLS PLUMB? FLOOR LEVEL?
GIVE DOOR OPENING—CLEAR WIDTH AND HEIGHT
HOW IS ACCESS TO VAULT OR ROOM—STAIRWAY OR ELEVATOR?
GIVE ELEVATOR DOOR OPENING AND INSIDE SPACE OF CAR
STOP AND THINK. CAN WORK BE TAKEN INTO SPACE AND ERECTED CONVENIENTLY?
Machinery

Fig. 9. Memoranda for Guidance of Draftsmen and Salesmen when taking Data in Field

* * *

Learning a trade is a good education for any young man. Learning to do things with the hands trains the brain, and even though a man may not intend to follow a trade as a means of livelihood all his life, the fact that he possesses knowledge of a trade will give him confidence and practical knowledge invaluable in any position in life.

LETTERS ON PRACTICAL SUBJECTS

WE PAY ONLY FOR ARTICLES PUBLISHED EXCLUSIVELY IN MACHINERY

PRESENT DEMAND AND STANDARDIZED PRODUCTION

A small manufacturer of lathes, shortly after the beginning of the war, decided that the demand for his product was such that he could sell all he could make of one size and style. He had been connected with the automobile industry and had learned its lesson of specialization. So he built 1200 lathes, all three-step cone, double back-geared, of not only the same swing, but also the same length. The length of bed was such as to load his planers most economically, and the other details were figured out in the same way. At the same time, he secured another shop and started building 800 lathes, slightly larger, identical throughout. Regardless of the nature of the request, he quoted on these two sizes of lathes and refused to change anything from the length to the smallest item of equipment. It took nerve, but it worked. His production jumped without an effort over 25 per cent, and the quality of the product was uniformly better.

There is, in this manufacturer's success, a lesson that is of especial importance just now when it is only a question of meeting the demand. It may not be that every plant can afford to cut down its line to one product. It may be necessary for a plant to hold its prestige in different lines, pending the return of normal conditions, and its equipment may not be adapted for so limited a product; but it will pay every manufacturer to study the lines he is producing and find which he can manufacture most profitably. He should see if there is enough business in those lines to keep his plant busy under normal conditions and concentrate on them now, when the demand will keep him busy. Then he can plan his marketing and improvements in his product, and study its manufacture and standardization, so that when business is again normal he will be able to secure enough of the line in which he specialized to keep his factory humming. Such a concentration will result in a simplifying of the machines and interior arrangement of his factory, with a corresponding reduction in the work of planning, routing and cost keeping. The greater efficiency that is bound to follow will do much to enable the manufacturer to maintain his production against the decreasing man supply.

Cincinnati, Ohio — D. M. PERRILL

OIL-GROOVE RECESSING TOOL

A short time ago an interesting problem arose that caused us considerable trouble. A certain oil-groove in a large casting that had previously been cored was to be finished as shown in Fig. 2. Owing to the small size of the bore, 1¼ inch, it was difficult to design a tool that would have sufficient strength and rigidity; and as this particular grooving operation was to be repeated at least 200 times every eight hours, a strong, durable tool was absolutely necessary. After some discussion, the design shown in Fig. 1 was decided upon. The tool-holder *A* is turned up with a semi-spherical tongued end, which rocks in a slot cut in the end of shank *B*. This tongue acts as a driver. A retaining collar, locked in place by means of a lock-nut and peened over at *C*, holds tool-holder *A* in place. The hardened steel bushing *D* is turned up on one end to fit into the bore of the work and a depression machined in the other end allows part *A* to rock in it. With the bushing in place and the center line of the shank in line with the center line of the bore, the tool is fed to the left as it revolves until surface *Y* coincides with surface *Z*. The tool bit will then have risen to the position shown by the dotted lines. Parts *A* and *D* are made of hardened tool steel, while collar *C* and shank *B* are of machine steel and casehardened. The cutter was made adjustable for the various depths of the different grooves, as well as to allow for grinding. Of course, distance *X* must be less than the bore of the work to permit the entrance of the tool. This tool has been in use for over three months, and, considering its rough usage and large output, it accomplishes its purpose remarkably well.

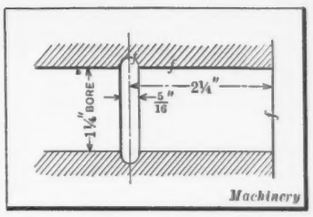


Fig. 2. Oil-groove to be machined

Chicago, Ill. — H. A. PETERS

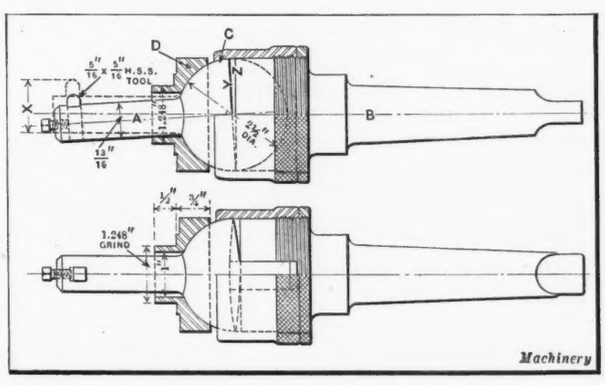


Fig. 1. Tool for finishing Oil-groove in Casting

REMOVING IRON PLATE RUST

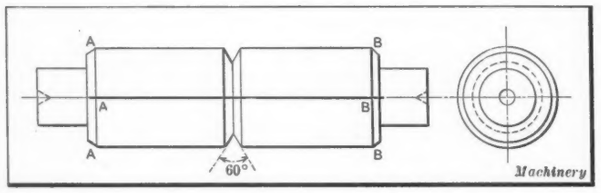
A cheap and effective method of removing rust from corroded and pitted iron plates has recently been evolved as a result of experiments. It consists in applying to the surface of the iron a mixture of two parts of finely crushed sodium bisulphate (sodium acid sulphate, Na_2SO_4, H_2SO_4, $3H_2O$) and one part of common salt, which is moistened just enough to make it cohesive. The moist mixture can be left on until the plate is clean, but the action is more rapid if the mixture is scraped off every two or three hours and the iron scrubbed thoroughly with a wire brush and water; the treatment is repeated until the plate is clean. Usually twenty-four hours is sufficient for a badly corroded plate. When the plate is thoroughly clean it is well washed with an alkaline solution, and dried quickly. A coating of paraffin oil (kerosene) is at once applied to protect the surface against oxidation. The metal is then ready for the paint or other protective covering. This method has been found to be more effective than hammering, chiseling, the use of wire brushes, or even a sandblast.

Liverpool, England — MARK MEREDITH

HANDY GAGE FOR SETTING UP THREADING TOOLS

The simple tool shown in the accompanying illustration has proved useful for setting up threading cutters in the lathe toolpost, when an accurate thread is required to be cut on a single piece. It consists of a piece of machine steel, about four inches long and one inch in diameter, that has been centered true at both ends and contains a groove with an included angle of 60 degrees turned about its periphery. Four lines *AB* are laid out longitudinally along the gage, 90 degrees apart. Hence, when one line is in alignment with a line on the top of the dead center of the lathe, the next line gives the proper height of the thread-cutting tool. The centers in each end of the gage are sunk deep into it at an angle of 60 degrees, so that it will revolve freely on the lathe centers.

The method of using this gage will be readily seen. The threading tool is put into the toolpost of the lathe, but is not



Handy Gage for setting Threading Tools

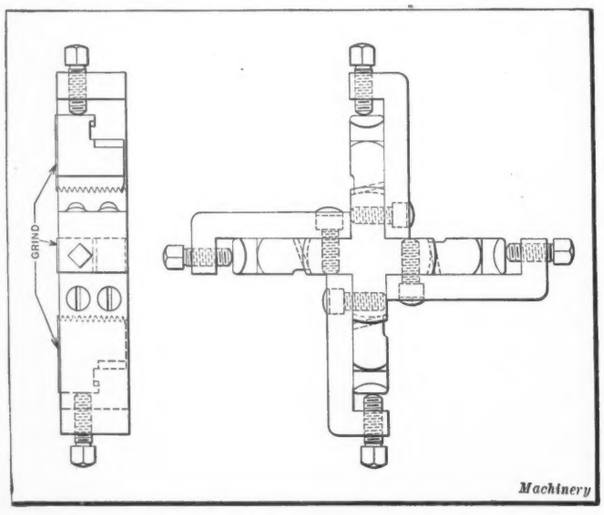
clamped tight; then as the cross-feed is gently fed into the setting-up block, the threading tool takes its proper position. The threading tool is then tightened, the setting-up block taken out of the lathe, and the work to be threaded is put into its place. This tool is most useful when various sizes of V-threads have to be cut.

New Haven, Conn. ERIC LEE

CORRECTION OF CHASERS

In almost every lot of chasers received there are three or four sets that do not line up properly, with results that anybody familiar with machine work knows. The writer does not know the precise cause of this, but the method used to correct the fault may be of interest to those who have similar difficulties. The head in which these chasers are used is of the self-opening style and the chasers are easily slipped into position and held in place by a collar. The style of head in which the chasers are used, however, is not very important, as the correction is equally positive for heads in which the chasers are held in place by screws. The method of correction is simply to grind the back end face of the chaser the necessary amount to bring the cutting points in the proper position in the set.

The grinding fixture consists essentially of a piece of steel properly threaded, out of which sections have been cut. The chasers are arranged in the order in which they go in the die-head with the cutting points engaged with the threads in



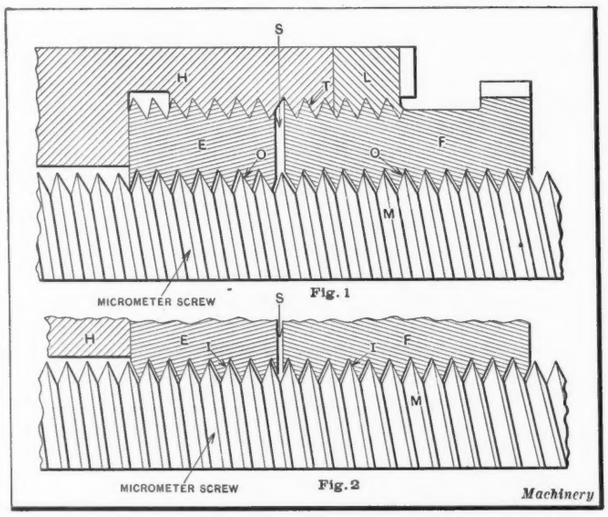
Fixture for grinding Chasers to Proper Alignment

the center piece. They are held in place by L-shaped brackets having set-screws at the ends. The brackets are held in place on the threaded piece by screws. With the brackets in place, and the set-screws adjusted, a half turn of the wrench will release any chaser or hold it firmly in position for grinding, which is done on the rear end surface or the end that slips back into the die-head. A sweep or two across the grinder and the slight correction necessary is made. As the work can be done very rapidly, it has saved the time of returning chasers to the factory and waiting for them to come back again. With the self-opening type of head, if the chasers are not slipped back to the limit when placed in the head, they will be driven into position when the work is advanced against them, and will be in perfect alignment, as the grinding is done at the rear end of the piece.

Boston, Mass. JOHN A. SHAND

WEAR OF MICROMETER SCREW AND NUT

The method of compensating for wear of screw and nut in a well-known micrometer introduces an interesting little wrinkle. To the writer, it is especially interesting because of the considerable number of persons, including himself, who overlooked it. The nut *E* is fixed in the hub *H*, its position and inside diameter remaining the same, and the tension, or feel, is obtained by advancing or withdrawing an auxiliary nut *F*. A lock-nut *L* holds the auxiliary nut *F* in position after the tension is adjusted. Moving the auxiliary nut *F*, either toward or away from nut *E* produces friction between the nut and screw *M*. Moving *F* away from *E* produces the conditions shown in Fig. 1; moving *F* toward *E* produces the conditions shown in Fig. 2. The difference is that, as adjusted in Fig. 1, the threads in nut *E* wear on the left-hand side and



Means of compensating for Wear of Micrometer Screw and Nut

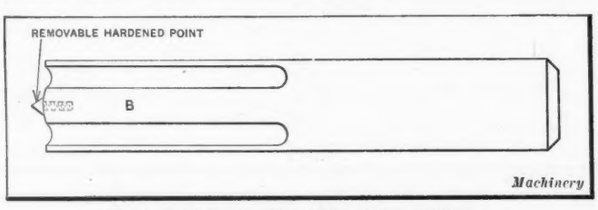
are free on the right-hand side; while the reverse condition exists when adjustment is made by moving *F* away from *E*, as shown in Fig. 2. When *F* is locked in position, *E* and *F* constitute one nut with provision for altering the lead at *S*. It thus produces friction on the outside sides *O* of the thread or on the inside sides *I*, according to the relative lead of the threads *T* and *M* and the direction in which the auxiliary nut *F* is moved.

The point that seems to be easily overlooked is that if thread *T* is the same lead and hand as the micrometer-screw *M*, screwing *F* toward or from the hub *H* will make no difference in the tension. Tension is obtained by the lead of the thread *T* being different from the screw *M*. Suppose that the lead of the thread *T* is 1/50 or 0.020 inch. As the lead of the screw thread *M* is 1/40 or 0.025 inch, a whole turn of the auxiliary nut *F* will vary the lead of nut *EF* 0.005 inch at *S*. If *T* were the same hand and faster than *M*, screwing *F* into hub *H* would produce the effect shown in Fig. 2; screwing it out, or away from *E*, would produce the effect shown in Fig. 1.

Wilkinsburg, Pa. WILLIAM S. ROWELL

SELF-CENTERING MARKING PUNCH

In connection with the erection of some tank work, it was necessary to drill a great many ¾-inch holes according to templets or duplicate pieces. In arranging this work, it was therefore customary to scribe the hole first from the templet onto the plate to be drilled and then approximate the center of the scribed circle and center-punch a hole to receive the



Handy Tool for locating Holes before drilling

tip of the drill. After the drill was started, it was often found necessary to shift the center because of incorrect location of the first punch hole. To simplify this operation and to eliminate the possibility of the punch hole being off center, the writer made the simple punch here shown. The tool is made of ¾-inch steel and is machined to fit inside the ¾-inch drilled hole on the templet. The lower end is arranged with four wings to hold the tool in the center and a piece of hardened steel is put exactly in the center of the bottom to act as the punch; this part is removable for sharpening and replacement. The templet is placed over the casting and the center-punch is inserted into the templet hole and struck with a hammer, the center-hole impression being made without any further work. This method has cut down the time for laying out the holes by more than one-half and has also saved considerable time because the center is accurately marked.

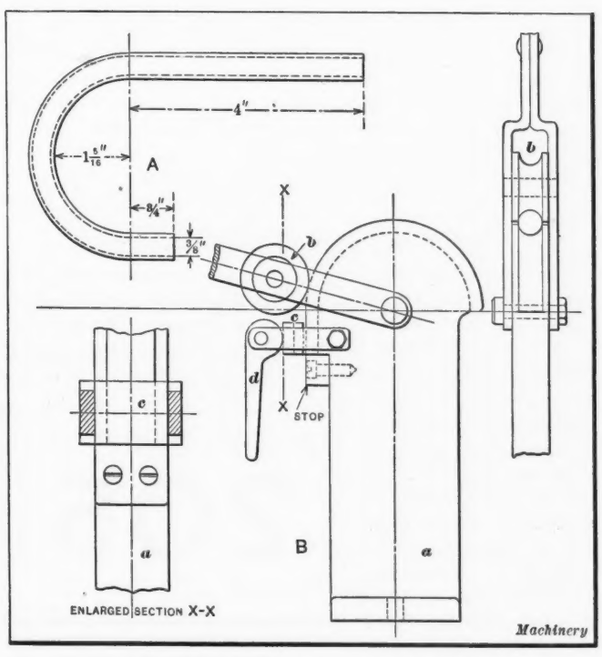
The tool is fluted because, in some cases, the holes in which it is placed are not perfectly round or some rust or a chip may have lodged in them, so that the center-punch will not enter the hole quickly. Therefore, by making four points of contact instead of a continuous contact, the chances for sticking or binding are reduced, for if a chip end should project at any point the flute will readily pass over it.

Philadelphia, Pa. W. A. LAILER

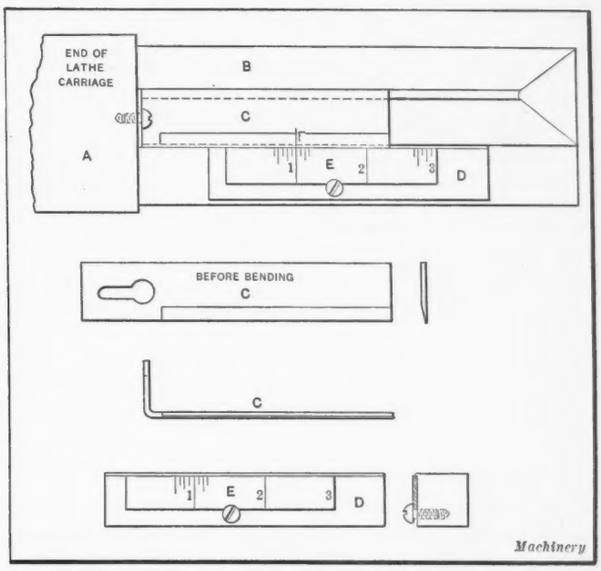
TUBE BENDER

The bending of tubes is always a more or less difficult matter, and the difficulty increases with the thinness of the walls of the tube and the shortness of the radius of the bend. Heavy gage tubes are comparatively easy to bend to a large radius without an excessive amount of flattening, but with a short-radius, thin-walled tube, it is quite a tedious piece of work to make a good-looking bend. The writer designed the tube bender shown in the accompanying illustration for a ⅜-inch tube about 0.010 inch thick, of the shape shown at *A*. The fixture illustrated at *B* consists of a cast-iron body *a* grooved to the proper radius for the bend required, of suitable dimensions to allow the tube to pass freely through the groove, and terminating in a straight portion. The runner *b* is of machine steel grooved to comply with the form of the groove of body *a*. The gripping jaw *c* is also grooved, and in practice is clamped to the end of the tube by means of the eccentric *d*. The device can be fastened to the work-bench or clamped in the vise. The operation is simple and efficient, and has never failed to work.

Brooklyn, N. Y. ERNEST SCHWARTZ



Tube Bender adapted for handling Thin Tubing



Gage for determining Desired Depth when performing Boring Operations on Lathe

DEPTH GAGE FOR BORING ON LATHES

The accompanying illustration shows a device that the writer made for determining when the desired depth has been reached when boring on a lathe; this gage may also be used for many similar purposes. At *A* is shown the end of the lathe carriage; *B* is the front V-bearing; *C* and *D* are parts of the gage, part *C* being fastened by a round-headed screw to the end of the lathe carriage, while part *D* is movable and held in place by its own weight. Line *F* on part *C* should correspond with the even inches on scale *E* when block *D* is against the end of the lathe carriage. To explain the use of this gage, suppose you have to bore a hole ⅞ inch deep. Set the boring tool against the face of the work and slide the gage up against the end of the lathe carriage. The boring operation is then started, and when line *F* comes under the ⅞-inch graduation on scale *E*, it indicates that the desired depth has been bored, and the feed is then disengaged. S. C.

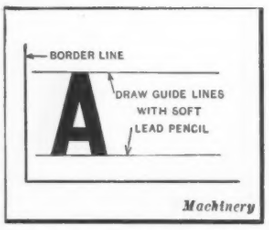
EFFICIENT KNURLING

Good knurling produces an excellent effect on the handles of plug gages and certain jig parts. Kerosene used freely will keep the tool and the work cool, and will also wash away all loose particles, which often cause inferior work. For plug-gage handles and other long knurled work, it is important that the tool be carefully set by testing it against the work before the feed is engaged. The spiral thread sometimes seen on long knurled work is caused by one knurl making a deeper impression than the other, the latter scratching against the top of the spiral thus cut; and is due to the failure to set the tool properly. It is the experience of the writer that two cuts are sufficient; that is, the knurl should be set full depth and a return cut taken without increasing the pressure. In cases where the knurl is a loose fit on the pin, the feed forces it to one side, causing it to cut only on the corner; this condition may be overcome temporarily by setting the tool to the side, and not taking any return cut. Passing over the work several times is unnecessary and only increases the possibility of chips and dirt getting in and producing a bad appearance.

Hartford, Conn. E. J. HIGGINS

METHOD OF LETTERING TRACINGS

It is a matter of common knowledge that many tracers and draftsmen who are otherwise capable of producing satisfactory work are unable to make good-looking letters and figures. That this is the case will be apparent to anyone who has to look over a lot of blueprints produced in different drafting-rooms. It frequently happens that tracings that would otherwise present a pleasing appearance have letters and dimension



Method of lettering Tracings by applying Black Paper Letters with Gummed Backs

numbers which are poorly made. To overcome this difficulty and also to save time in lettering, I have adopted the practice of using black paper letters and figures, which are gummed on one side so that they may be stuck to the tracing. Guide lines are drawn on the tracing so the lettering will be in proper alignment. This method will be appreciated by all draftsmen and engineers, as it produces a neat, workmanlike looking result and can be finished in a few minutes. These letters and figures can be purchased in any size, and are gummed on one side for attachment to the tracing after they have been moistened.

Flint, Mich. C. C. SPREEN

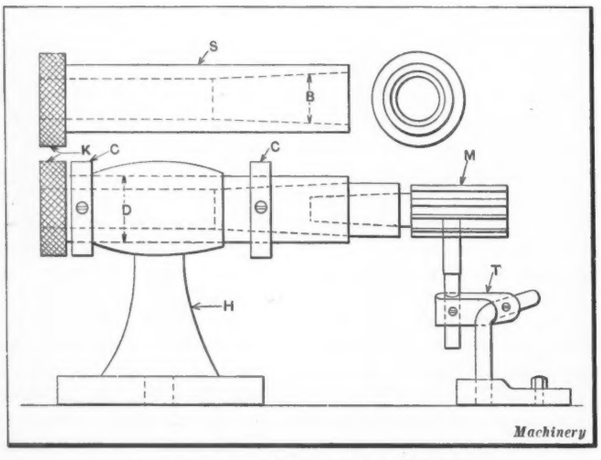
MAKING CHASERS IN THE LATHE

As the writer has made thread chasers at different times, he is always interested when he sees anyone making them, but he has never seen any method that excels the one he learned when an apprentice. A tap, preferably a large one, of the pitch the chaser is to be, is mounted between the centers of an engine lathe and the chaser blank is placed in the tool-post. The chaser is then fed in and the carriage feed-nut engaged the same as when chasing a thread. By this method, the chaser is finished in a short time as compared with the shaper methods the writer has seen tried. It is to be admitted that the circular chasers are better, but they cost more to make than some jobs warrant.

Cleveland, Ohio L. J. ORR

ATTACHMENT FOR GRINDING TEETH OF END-MILLS

The accompanying illustration shows an attachment for grinding the peripheral teeth of end-mills, so that they will be parallel with the axis and will run absolutely true when in use. The steel sleeve *S* has a knurled collar and is bored at *B*, preferably of the same bore as the milling machine arbor, to



Attachment for grinding Teeth of End-mills

receive the cutter sockets. This sleeve also has two adjustable collars *C*, that regulate the travel to correspond with the length of the cutter *M* to be ground. The casting *H* may be the regular headstock furnished with some grinders, carrying a sliding sleeve, which, in turn, carries a driving arbor, but if the grinder is not furnished with this design of headstock, or if the bore *D* is not large enough to receive the sleeve *S*, a casting must be made that will answer the requirements. Either spiral or straight flute mills may be ground with an equal degree of accuracy.

Another advantage of this attachment is that the stop-finger may be secured to the table and the proper clearance obtained by simply raising or lowering the table, eliminating the necessity of fastening the finger to the wheel-head, which disturbs the finger setting when the table is raised or lowered. The finger should be somewhat wider than the wheel and should be set in line with the wheel face. By gripping the knurled collar *K* lightly with the fingers, the sleeve is easily fed through its travel.

Bremerton, Wash. STANLEY EDWARDS

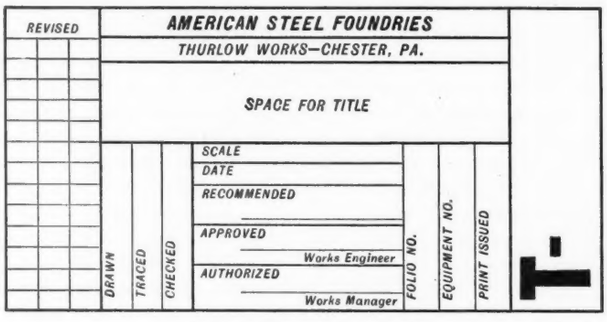
INDISPENSABILITY

The indispensable employe should be discharged as a danger to the employer. Further, he stands in his own light, as "indispensability" is in the way not merely of an occasional extra holiday but also of promotion, for someone must be brought in from outside to fill a higher position.

New York City ROBERT GRIMSHAW

DRAWING TITLE

In the accompanying illustration is shown the standard title used on drawings of one large shop; these titles are printed on blank sheets of tracing cloth, ready for the draftsmen. All



Complete Title for a Drawing

the drawings are 25½ by 22 inches, or 11 by 17 inches, both of which are multiples of the standard letter size paper, namely, 8½ by 11 inches, and are folded to the letter size when being mailed. A "T" is placed in the lower right-hand corner of the title and in the lower left-hand corner of the tracing; this stands for Thurlow (Thurlow Works). The drawing number is placed next to this letter, so that when finished it will read T-1524, etc.

Chester, Pa. GEORGE W. CHILDS

GRINDING-ROOM KINK

If fine cotton is wound on the spindle of an outside micrometer caliper in the small space between the short nut and the frame, the thimble rubbing against this cotton will unfailingly wipe away any particles of emery and prevent their getting near the thread of the spindle.

Hartford, Conn. E. J. HIGGINS

NUMBERS FOR MACHINES

Sign plates similar to that here shown have been found very satisfactory. They are made by punching the numbers out of iron or steel plates and then painting the plates yellow, red, or some other bright color. As these plates are suspended from the ceiling no time is lost looking for numbers that have been covered or misplaced by the men.

A number plate is hung above each place at which a man is working. Then when the foreman instructs his trucker to transfer material from number 25 to number 110, or if he asks the millwright to fix machine number

Number that may be hung over Machines, Benches, and Assembly Stands

50, the men can find these places without asking. Punching the figures out of sheet iron saves the expense of repainting the plate and the numbers at short intervals; the oil, dust, smoke, grease, etc., soon make painted figures unreadable. With perforated figures, however, it is only necessary to repaint the body of the plate, as the numbers always remain the same.

Flint, Mich. C. C. SPREEN

TAPER GAGES

In Fig. 1 is shown a quick method of testing the size and taper of pieces; *P* are the parallels of the taper gage and *G* is the gage to be tested. It is first necessary to find the size of a disk that will touch the end of the plug and parallels of the taper gage. The angle of the taper with the center line must be found to get the sizes of the disks for setting the taper gage; it can be taken from a table of tapers or can easily be calculated, knowing the tangent.

The angle *ABC* is equal to 90 degrees less the angle of the taper with the center line. *AB* is equal to *BC*, for the tangents to a circle drawn from an external point *B* are equal, and a line *BO* drawn from *B* to the center bisects the angle *ABC*, making the angles *OBA* and *OBC* equal. *BC* is equal to one-half *BD*, which is the given dimension of the small end of the plug gage. *OC* is equal to *BC* times the tangent of the angle *OBC*, and twice *OC* is equal to the diameter of the disk.

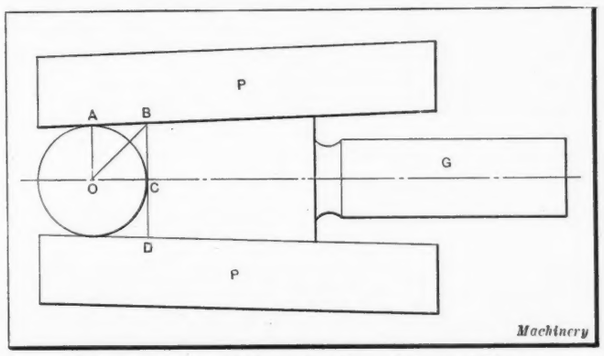


Fig. 1. Gage for quickly testing Size and Taper of Pieces

In Fig. 2 is shown a method of testing the depth of thread in a tapered thread piece. By this method the amount that a wire in a taper thread will increase the size of the small end of the piece is found. From the center of one thread to the center of the next on the taper is equal to the linear pitch divided by the cosine of the angle with the center line. Angle *EDF* is equal to the thread angle; angle *EFD* is equal to the thread angle less the angle with the center line; and the angle *FED* is equal to the thread angle plus the angle with the center line. The width of the flat must be taken from the center to center distance of the thread, which equals, in usual practice, one-twenty-fifth of the pitch, and gives the distance *EF*. Find one side *ED* of the thread from the proportion *ED*:*EF* = sin *EFD*:sin *EDF*; and find the depth *AD* of the thread from *AD*:*ED* = sin *AED*:sin *EAD*. Angle *EAD* is equal to 90 degrees less the angle with the center line.

The diameter of the wire corresponds with straight threads, except in large center angles. From the center of wire *O* to apex *D* of the thread is equal to the diameter of the wire for a 60-degree thread. Angle *COB* equals the angle with the center line. *OB* equals *OC*, the radius of the wire, divided by the cosine of the angle *COB*. *OA* is equal to *AD* less *OD* and *AB* is equal to *OB* less *OA*. Twice *AB* added to the small end of the plug is the diameter of the small end of the plug.

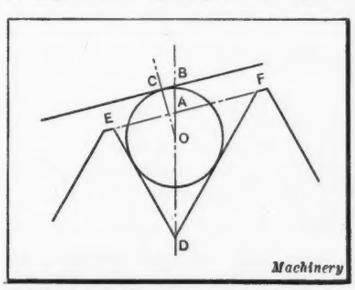
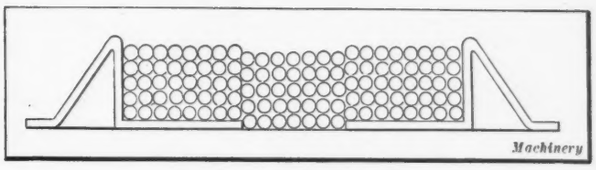


Fig. 2. Testing Depth of Thread of Tapered Thread Pieces

ROBERT W. SMITH
Indianapolis, Ind.



End Irons for piling Bar Stock

U-STAKES FOR PILING BAR STOCK

With regard to the use of U-stakes for piling bar stock, as explained in the August number of MACHINERY, the writer would say that he has found the method unsatisfactory for round bars. The U-stakes spread out before the space between them is filled, and, of course, two or more stakes cannot be piled on top of one another. The end irons shown in the accompanying illustration may be used with success, however. These irons are made from any scrap that may be at hand.

Cleveland, Ohio L. J. ORR

USE FOR DISCARDED TRACINGS

Old and discarded tracings on cloth are of no value to anyone, but they would make good bandages and handkerchiefs for the soldiers. In every drawing-room there are a great many such tracings that will never be of any use. These could be washed, ironed and turned in to the Red Cross. Any laundry should wash and iron these free of charge, but if these old tracings are sent prepaid to us, we will run them through our shop laundry. After they have been washed, they will be made into handkerchiefs and bandages and turned over to the Red Cross. Now is the time to clean out your old files.

CHARLES W. SHARTLE,
Middletown, Ohio President, Shartle Bros. Machine Co.

ONE-REVOLUTION CLUTCH

The two types of one-revolution clutch presented herewith have proved both satisfactory and inexpensive. In Fig. 1, the driving pulley rotates clockwise. Hardened steel bushing *A* is driven into the pulley; hardened steel collar *B* is pinned to the shaft; cage *C* extends between the bushing and collar, and is milled to retain three hardened steel rollers *D*; it also is provided with a stop-pin *E* driven into its outer surface, and a spring *G* tending to pull it in a clockwise direction.

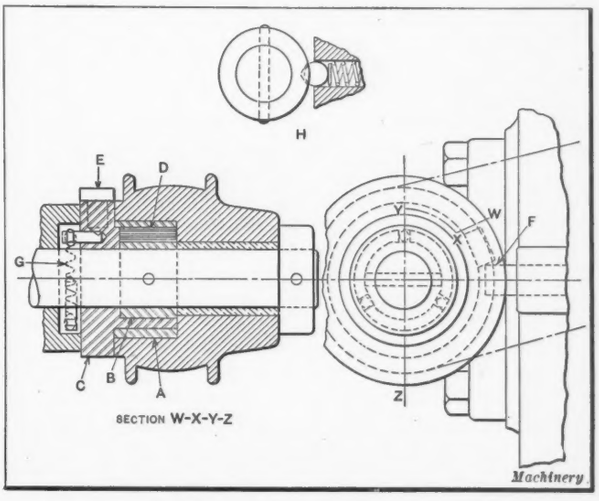


Fig. 1. One-revolution Clutch in which Drive is obtained by jamming Hardened Rollers between Driving and Driven Members

Collar *B* has three flats milled on its outer circumference, and when it is in the position shown, the space between bushing *A* and these flats on collar *B* is sufficient to allow the rollers clearance. However, when rod *F* is withdrawn, spring *G* gives cage *C* a slight twist, jamming the rollers between the bushing and collar, and thus driving the shaft. After one revolution, rod *F* has returned to the position shown, and

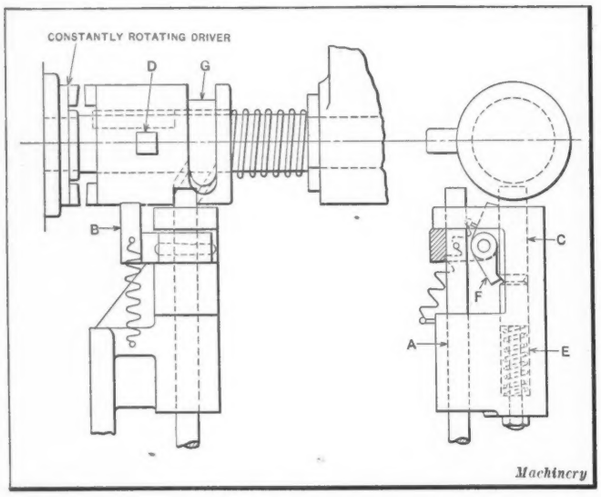


Fig. 2. One-revolution Clutch in which Teeth of Clutch are released by Cam after One Revolution has been completed

striking stop *E* causes the rollers to be thrown back into their former clearance, thus disconnecting the two members. It is necessary to provide the shaft with a corrector, which is shown at *H*, in order to have it stop accurately.

To engage the clutch teeth, rod *A*, Fig. 2, is lowered, drawing pawl *F* and rod *C* downward. This brings pin *D* in line with lever *B*, and groove *G* in line with rod *C*. As the clutch revolves, pin *D* strikes lever *B*, releasing rod *C*, which, by the expansion of spring *E*, is snapped into groove *G* milled in the clutch. This groove is cammed at a certain point, and as the rod is held in its bearings, the clutch teeth are withdrawn at the end of one revolution. C. O. H.

COMPUTATION OF PI

One of the most curious traits of human nature is that which has caused certain individuals in all ages to pursue mathematical and other problems far beyond the point necessary for the use of mankind in general. In the dark ages of medieval history, mathematical research was absolutely dormant. The scientists of those days spent their time in the vain quest of the philosopher's stone and the elixir of life. Indeed it is hard to say that research in connection with these two is dead even at the present day. One sees occasional reports in the papers that someone is trying to turn lead into gold with radium emanations, X-rays, and so forth, while the recent boom of the pituitary gland by the lay press is only a revival of the old idea of the elixir of life. At the same time it behooves one to write cautiously on these matters. During the eighteenth century, mechanical flight was "impossible," but mechanical flight was a dream of the philosopher long ago in ancient Greece and nowadays an aeroplane flight of 500 miles or so scarcely arouses comment.

The three great "fad" problems of the ancient geometricians were the duplication of the cube, the trisection of the angle, and the quadrature of the circle. The last is of interest to the mechanic from the fact that in approaching many mechanical problems he must use the convenient ratio, which he knows as "pi." Looking way back, one can find very little about this ratio, but it appears to have been accepted as 3 by the Chinese and Babylonians. From a lengthy description in the book of Kings, of a commission given by King Solomon to Hiram, a brass worker of Tyre, for the manufacture of a molten sea, one gathers that pi was 3 among the ancient Jews as well, for it states that the molten sea was ten cubits from brim to brim and thirty cubits round about. Among the ancient Egyptians, according to the only reference that has been found, the ratio of the circumference to the diameter is equal to $\sqrt{10}$, or 3.16, a value too large but much nearer the real value than 3.

The first person to give the matter any serious attention, was Archimedes, who proceeded on the following line of reasoning: If two polygons of many sides are constructed, inscribing and circumscribing a circle, the mean value of the sum of the sides of the polygons will give a close approximation of the value of the circumference of the circle. He laboriously constructed many polygons in this manner, ending his researches with one of ninety-six sides, by means of which he conclusively proved that the value of pi lay between 3 10/70 (the circumscribing polygon) and 3 10/71 (the inscribed polygon) times the diameter of the circle. He also stated that the circumference of a circle 4970 feet in diameter lies between 15,610 and 15,620 feet, an exceedingly close value considering the limitations of his day, as the real circumference is 15,613 feet, 9 inches, very nearly.

It is unknown who next attacked the problem, but from Hindu writings about 500 A. D. it is evident that someone had done considerable work on it, for the fraction 3927/1250, or 3.1416 exactly, was in common use, which is the commonly accepted value today, as this fraction complies with ordinary commercial requirements. Another thousand years elapsed before any further attempts to square the circle were made, but then pi computers came thick and fast. The first to effect a closer valuation was Adrian Metius, a Dutch mathematician of the fifteenth century, who succeeded in showing that the real value of pi lay between 3 17/120 and 3 15/106. To him is due the wonderfully close approximation (which represents the limit of any commercial or scientific necessity) 355/113, which he found by taking the mean of the two stated fractions, by simply halving the sum of the numerators and denominators of the two fractions; thus,

$$3\,\frac{(17+15)\div 2}{(120+106)\div 2} = 3\,\frac{16}{113}.$$

He luckily hit upon the value correctly to the sixth decimal place.

Honors did not long remain with Metius, however. He was quickly followed by De Viette, who by the incredible labor involved in investigating polygons of 393,216 sides, published in 1579 the result correctly to the tenth decimal place. This mathematician, however, used a greatly improved method in dealing with the subject, owing to the improvements in mathematical knowledge, which was now advancing by leaps and bounds. Adrian Van Roomen, a Flemish worker of Louvain University, published the ratio correctly to the fifteenth decimal place in 1593. The most famous worker of the middle ages, however, was Ludolph Van Ceulen, who died in 1610, and his life's work was engraved on his tombstone in a Leyden church to the effect that the ratio of the circumference to the diameter of the circle is more than 3.1415926535-89793238462643383279502 88 and less than 3.1415926535897932-384626433832795028 9; truly a wonderful monument of a misspent life. In 1596, he had published the result correctly to twenty decimal places so that the last fifteen places must have occupied at least the most of the remaining fourteen years of his life. No useful purpose is served by naming in detail the many workers on the same subject since, for the problem was attacked by nearly all the famous mathematicians in turn. By 1630, Grienberger had carried it to thirty-nine places; by 1699 Sharp had carried it to seventy-one; in 1702, Machin carried it to one hundred places, and in 1719 De Lagny carried it to one hundred twenty-seven.

Until 1761, pi was supposed to be a finite quantity, but mathematical reasoning by this time was on such a firm basis that Lambert was able to prove conclusively that it was incommensurable. Notwithstanding this fact, the ardor of the pi computers remained undiminished. Even Hutton (of logarithmic fame) fell under the spell and carried out the ratio to one hundred thirty-six places. The vast amount of work performed on the problem in the last century may be dismissed in a short table:

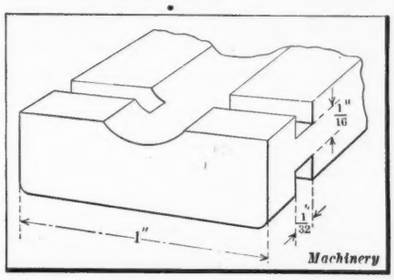
1842, pi = 3. (208 decimal places), Rutherford
1847, pi = 3. (250 decimal places), Clausen
1853, pi = 3. (318 decimal places), Shanks
1853, pi = 3. (440 decimal places), Rutherford
1853, pi = 3. (530 decimal places), Shanks
1853, pi = 3. (607 decimal places), Shanks
1873, pi = 3. (707 decimal places), Shanks

No doubt even at the present day the race continues for the honor of computing the thousandth place, nine hundred and ninety of which have no practical value whatever. Those

who would like to study the mathematical processes on which the results are founded should read the article "Squaring the Circle" in the Encyclopedia Britannica, which also gives an extensive bibliography on the subject. A. C. B.

ROBSON & SORENSEN TWO-PART BALL BEARING

I have read in the September number of MACHINERY the descriptive article on the Robson & Sorensen two-part ball bearing, and have a few criticisms that I would like to make. The conditions described in the first two paragraphs of the article do exist, and it is these conditions that have made the two-part bearing a failure. It is also true that if the load could be relieved from the balls as they pass over the joints in the raceway, practically no damage would result. The statement is made: "Realizing the importance of this point, it was decided to provide means for relieving each ball in the bearing of its load as the ball passes over one of the joints in the raceway." The device invented by the makers of this bearing would tend to produce the desired result provided the section adjacent to the joint were actually deflected, but since it is stated that pressure on the ball is relieved when the ball reaches this section, it is hard to conceive how a deflection can occur without the application of a load.



Approximate Conditions for No. 309 Bearing

If the section near the joint drops 0.001 to 0.002 inch below the section toward which the ball is advancing, there must be a load in order to cause this drop, and the load must be rather heavy, notwithstanding the assertion that deflection is only 0.001 to 0.002 inch. A very simple calculation will show that the load is rather a dangerous one. It is not stated whether the illustrations in Figs. 1 and 2 are to scale, but it appears safe to assume that for a bearing known to the trade as No. 309 the dimensions of this reduced section adjacent to the joint would be approximately as shown in the illustration; width, 1/32 inch; thickness, 1/16 inch; length, about 1 inch. The last dimension is the width of the bearing. We have, therefore, the condition of a simple cantilever fixed at one end and loaded at a point 1/32 inch from the fixed end. The deflection of such a beam is found from the well-known formula:

$$D = \frac{PL^3}{3EI}$$

where P = load;
L = length;
E = modulus of elasticity;
I = moment of inertia of section.

Solving this equation for the load, we get:

$$P = \frac{3DEI}{L^3}$$

Assuming that $E = 28{,}000{,}000$, the remaining quantities have the following values: $D = 0.002$ inch, maximum; $I = \frac{1}{49{,}152}$ (This is an approximate value, since the curvature of the section at the raceway has not been considered); and $L = 1/32$ inch. Substituting these values in the second formula, we find that the load required to produce a deflection of 0.002 inch is somewhat over 110,000 pounds. This is by no means negligible. While the deflection may be rather slight, the fact must not be overlooked that the beam is also quite short. No matter which way the thing is reasoned out, it appears that the device is impracticable. If the load is relieved, as stated, the section adjacent to the joint will not deflect and the bearing will possess the same defects as all other bearings of this type. If the section adjacent to the joint does actually drop a sufficient distance to cause the ball to pass over the joint without damage, then the load is bound to be a dangerous one.

New York City ASHER GOLDEN

Mr. Golden's criticism of our two-part ball bearing has confirmed my impression that there is likely to be a misunderstanding of the features of the split or two-part ball bearing among those who have not made a detailed study of bearings of this type. I trust that the following explanation and illustration will assist in clearing up any possible misunderstanding among readers of MACHINERY concerning the operation of bearings of this type.

Referring to Mr. Golden's letter, I call attention to a quotation in the first paragraph: "Realizing the importance of this point, it was decided to provide means for relieving each ball in the bearing of its load as the ball passes over one of the joints in the raceway." This statement should read that means are provided to relieve each ball in the bearing of a considerable portion of its load as the ball passes over one of the joints in the raceway. How the ball is relieved of a portion of its load is best explained by referring to the illustration, which shows a development of the inner and outer raceways with balls *A*, *B*, *D* and *E* distorted by the load they are carrying; for the sake of simplicity, the outer ring and cone are not shown distorted. Ball *C* is the one in which we are chiefly interested, as it has resumed or nearly resumed its true spherical shape by the following process:

As this ball approaches line *FG*, it is in a distorted condition, due to being rolled between non-yielding (assumed for explanatory purposes) surfaces of the inner and outer raceways of the loaded bearing. When ball *C* reaches line *FG* it rolls forward toward the end of the cantilever beam and deflects this beam by nearly the same amount that the ball has been distorted. Therefore, it can readily be seen that the ball when passing over joint *L* is carrying an infinitesimally small load compared to what it would be capable of carrying. When in such a state it can practically do no harm to itself or the raceways while passing over the joint, although it is our practice to stone a slight "radius" on the ball tracks at the corners *M* and *N*. Assuming that the diameter of the balls in the illustration is 3/4 inch, which is the size chiefly used, the length of the cantilever beam, instead of being 1/32 inch, as Mr.

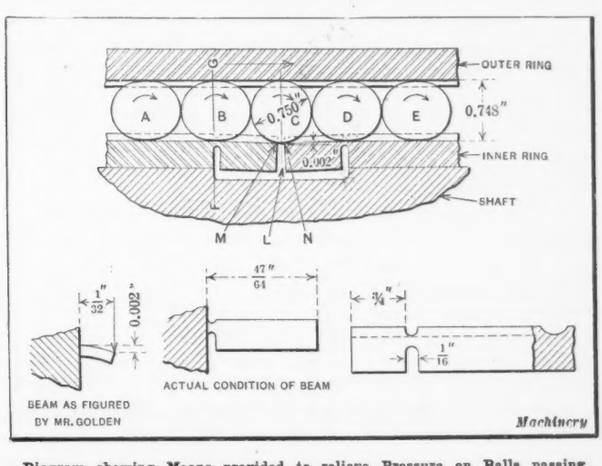


Diagram showing Means provided to relieve Pressure on Balls passing over Joints in Bearing Races

Golden has calculated, would be 47/64 inch, *i. e.*, more than twenty-three times greater. Substituting this value in the equation for the pressure, we find that increasing the value of L from 1/32 to 47/64 inch results in reducing the value of pressure P to 14.81 pounds. This beam is not of regular cross-section throughout its entire length, as the illustration shows; the width of the slot is 1/16 inch and is milled by convex cutters.

C. E. ROBSON
Spring City, Pa. Robson & Sorensen

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

INDEXING FOR MINUTES AND SECONDS

C. B. B.—I have a vernier scale that I wish to graduate on a dividing head of a milling machine, in the following divisions: twenty spaces in 3 degrees, 10 minutes, or 9 minutes, 30 seconds to each division. What is the ratio of the differential gearing for this operation?

A.—If there is a Brown & Sharpe differential index head available, use the following gears with one idler: gear on spindle, 86 teeth; first gear on stud, 81 teeth; second gear on stud, 34 teeth; and gear on worm, 32 teeth. If the above machine has the Brown & Sharpe equipment, two special gears must be used. Use an index plate with 49 holes, and taking one hole at each indexing, the result will be a movement of the head of 9 minutes, 30 seconds. A method of compound indexing for small angles was published in MACHINERY, August, 1914, page 1062.

CEMENT FLOORS IN BASEMENT

W. A. S.—Are cement floors cold and damp? For example, would it be feasible to use a basement of a building the floor of which is 4½ feet under ground and made of concrete? Should the floor be covered if used for office purposes?

A.—Cement floors have the reputation of being "hard" on workmen's feet. The trouble is not the physical hardness of the concrete, but the heat conductivity that results in abstracting the heat from the workmen's feet, causing them to swell and become painful; in other words, to become rheumatic. If means are provided for heating concrete floors, they are no "harder" than any other floor. The reason that workmen use mats or wooden gratings in front of machines to stand on in shops provided with concrete floors is to secure heat insulation, and not softness. We would advise covering the floor in question with tar paper and then laying linoleum over the paper. The combination of tar paper and linoleum should provide sufficient heat insulation to insure comfortable working conditions.

ROLLING INTERNAL THREADS

J. A. S.—Is it possible to roll an inside thread? Has anyone ever rolled internal threads and if so, what is the formula? We have no trouble in rolling outside threads by using a roll of the same diameter as the work or larger, according to formulas, but for inside threads the roll must be smaller than the work in order to enter the hole. Our problem is to roll a thread in a 1⅜-inch hole, fourteen threads per inch, Whitworth standard.

A.—Internal thread rolling is seldom done and is not regarded as a feasible proposition. The trouble is that very heavy pressure is required of the roll against the work in order to displace the metal, and it is difficult to support the work with the necessary rigidity and to provide a bearing for the roll that will stand up. The thread roll working on external work comes in contact with a comparatively small area, but when working on the inside of a hole the area of contact between the roll and the work is much larger relatively. Hence, in order to displace the metal required to form the thread, a pressure is necessary that is several times that required for rolling external threads of the same pitch. The internal thread roll should be made as small as permissible, having in mind the interference of the thread angles and the necessary diameter of the bearing. The smaller the roll the less the pressure required.

SETTING SHAPER HEAD TO CUT OFF CORNER OF BEVELED WORK

B. E.—We have some ½- by 2-inch pieces with the ends cuts to 20 degrees, and it is desired to cut off the corner at 45 degrees. We do not know how to figure out the setting of the shaper head. By trial, this is found to be about 15 degrees.

A.—The work and the lay-out for finding the angle are shown in the accompanying illustration. The lay-out shows all the lines revolved onto the horizontal plane. First, draw the line *R* for the direction of ram travel. The work is to be set in the vise and revolved horizontally 45 degrees from the setting that was used when cutting the slope of 20 degrees on the end. The ram will then follow the line *AB* across the corner. Then through the upper corner of edge *C* draw the tool feed line *F* at 90 degrees to *R*. The problem is to find the angle of this line with the vertical, so as to set the toolhead properly to follow down the plane of the 45-degree cut-off. First, calculate the horizontal projection *D* of the corner *C* that is to be cut off.

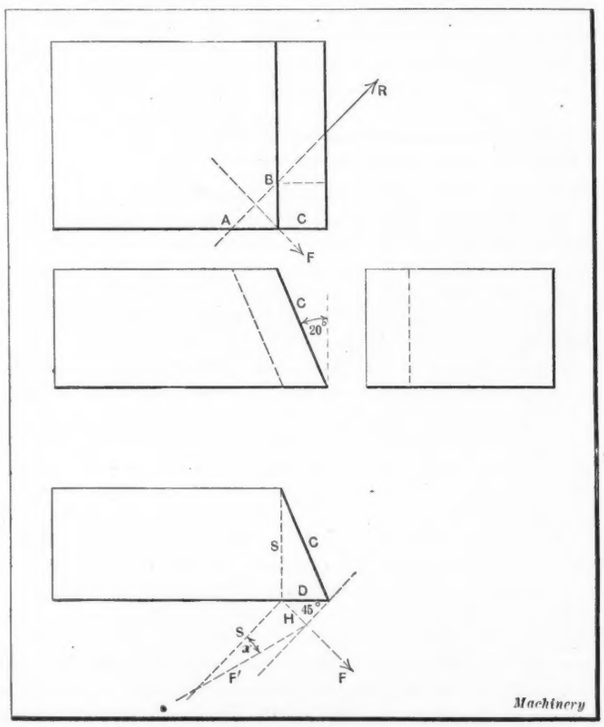


Diagram illustrating Method of setting Shaper Head to cut off Corner of Beveled Work

$D = S \times \tan 20 \text{ degrees} = ½ \times 0.36397 = 0.18108$ inch

Then, having *D*, calculate *H*, which is the horizontal feed of the tool while making a vertical feed of ½ inch. It will be observed that *H* is the intercept on the feed line *F* between parallel lines drawn through the ends of *C* and at 90 degrees to *F*.

$H = D \div \sqrt{2} = 0.18198 \div 1.4142 = 0.1286$ inch

Finally, having the horizontal feed of 0.1286 inch and the vertical feed of ½ inch, we have *F'* as the actual feed and the angle *x* which was to be found.

Tan $x = H \div ½ = 0.1286 \div ½ = 0.2572$, and angle $x = 14$ degrees, 30 minutes. W. F. B.

QUARTER SQUARES

R. A. A.—A book I was recently reading recommends the use of quarter squares or logarithms for making certain calculations. Will you please explain what is meant by "quarter square?"

A.—Quarter squares are sometimes used for performing multiplication, particularly when a series of numbers is to be multiplied by a constant number; in certain cases they are more convenient to use than logarithms. Let *a* and *b* be two factors, the product of which is desired, and assume that *a* is greater

than b. Then the following identical equation may be written: $\frac{1}{4}(a + b)^2 - \frac{1}{4}(a - b)^2 = ab$. Hence, a table giving one-fourth the square of numbers (whence the name, quarter square) may be used to find the product of two numbers by simply finding the sum and difference of the two factors and then taking the difference of the quarter squares of the sum and difference. For example, suppose that the product of 747 and 3.14 is required. For the sake of simplicity of calculations, the decimal point may be ignored. Here $747 + 314 = 1061$; $747 - 314 = 433$; $\frac{1}{4} \times 1061^2 = 281430.25$; $\frac{1}{4} \times 433^2 = 46872.25$; and $281430.25 - 46872.25 = 234558 = 747 \times 314$. Therefore, $747 \times 3.14 = 2345.58$. In tables of quarter squares, the fraction $\frac{1}{4}$ is always omitted, since it always cancels in subtraction. An ordinary table of squares may be used, provided the result is divided by 4. Thus, $\frac{1}{4}(a + b)^2 - \frac{1}{4}(a - b)^2 = \frac{(a + b)^2 - (a - b)^2}{4} = ab$. The table of powers, roots and reciprocals, pages 1–41 of MACHINERY'S HANDBOOK, may be used to find the product of any two factors having three significant figures each or of any two factors whose sum is less than 2000. Thus, in the above example, find the sum and difference of the factors as before; then, $1061^2 - 433^2 = 1125721 - 187489 = 938232$, and $938232 \div 4 = 234558 = 747 \times 314$, as before. The advantage of using quarter squares instead of logarithms in finding the product of two factors is that the operations are simpler and less in number, and there is less likelihood of making a mistake. There is also a saving in time, and there is never any doubt regarding the last figure of the product. The decimal point is placed after the product has been found by the regular rules of arithmetic. Quarter squares cannot be used for division. J. J.

PRESSURE ON A TOGGLE-OPERATED DISK CLUTCH

H. A. H.—In Fig. 1 is shown a section through a disk clutch operated by a shifting collar and toggle levers. Can you give me a method of calculating the pressure exerted on the disks at point A? The force assumed to act on collar D is 50 pounds and its movement is 1¼ inch.

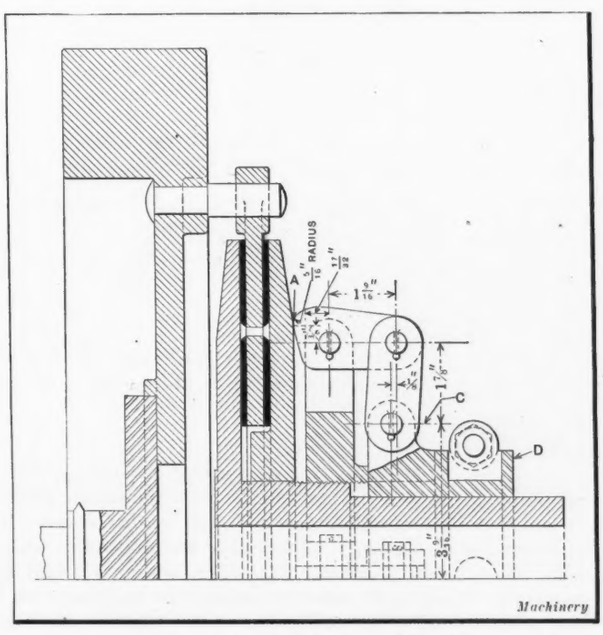


Fig. 1. Clutch shown in Engaged Position

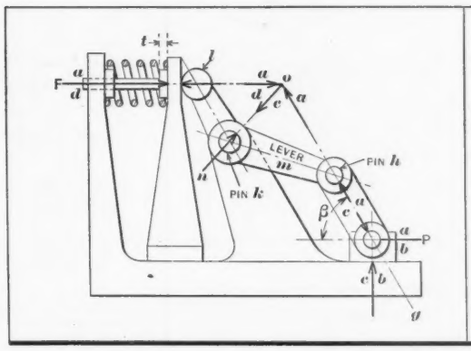


Fig. 2. Toggle Linkage Diagram neglecting Friction

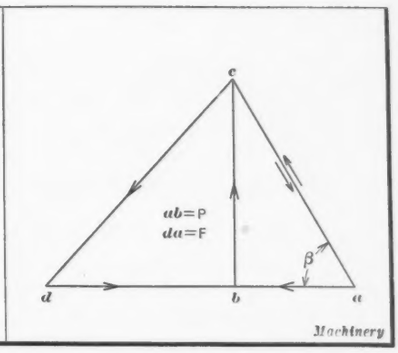


Fig. 3. Graphic Solution of Forces in Fig. 2

Answered by John S. Myers, Philadelphia, Pa.

Considering first the toggle-joint linkage, the simplest solution of such problems is by the graphic method. Fig. 2 represents in diagrammatic form, somewhat exaggerated for purposes of illustration, the elements of the device to be analyzed and Fig. 3 represents the graphic solution of the forces acting. In Fig. 2, the letters on both sides of a force designate it, while in Fig. 3 forces are designated by similar letters placed at the ends of the lines.

The operating force $P = ab$ is held in equilibrium by the vertical force bc and the oblique force ca. If the line of direction go of the force ca is produced until it intersects the line of direction of F at o, it will be obvious that, for this particular location of the linkage, pin h might lie anywhere along line go and have the same normal lever arm about pin k. Also the other end of the lever l might lie anywhere on line Fo and still have the same normal lever arm. It is possible then to consider forces ac and da to be applied at point o. Now if lever m is in equilibrium the resultant of forces ac and da must pass through the center of the fulcrum pin k and also through the point o; hence the line no gives the direction of the resultant force cd. Lay out to some convenient scale, as shown in Fig. 3, $ab = P$ and complete the diagram, drawing the lines parallel to those similarly lettered in Fig. 2. Then $da = F$ is the result sought. An inspection of Fig. 3 will show that as angle β approaches 90 degrees the forces cb cd, and da increase very rapidly, until at $\beta = 90$ degrees they become infinite. The significance of this is that, since no device can be infinitely strong, the load a toggle joint can develop depends not only on the applied force P but on the spring or resilience of the parts. This is represented in Fig. 2 by indicating the force F to be overcome as being applied through a short stiff spring. Now if S = scale of this spring, that is the pounds load per inch of deflection, and t = deflection, this force is then:

$$F = St \qquad (1)$$

If the available power P for operating the device is definitely limited, the angle β and the arms of the lever m must be so proportioned that the force P is able to overcome the force F. In the clutch shown in Fig. 1, the spring of the disks, the resilience of the liner, and the deformation of the linkage act in a manner similar to the spring shown in Fig. 2. Friction of the linkage also plays an important part in such problems. This may best be taken care of in the graphic analysis by the method used in connection with Fig. 7, on page 986 of the July, 1917, number of MACHINERY. This method is applied in Figs. 4 and 5. Here any line of force, instead of passing through the center of a pin, is drawn tangent to a circle having a diameter

$$f = JC \qquad (2)$$

where J = journal or pin diameter; C = coefficient of friction.

Forces bc and de are not inclined in Fig. 4 to take into account the sliding friction of the blocks, because in the actual clutch of Fig. 1, three or four, preferably three, sets of links are mounted on collar D and eliminate friction.

A number of stress diagrams similar to Fig. 5 may now be laid out for various positions of the linkage and the results plotted in curves similar to those shown in Fig. 7. The resilience of the parts may be estimated and a line CD, repre-

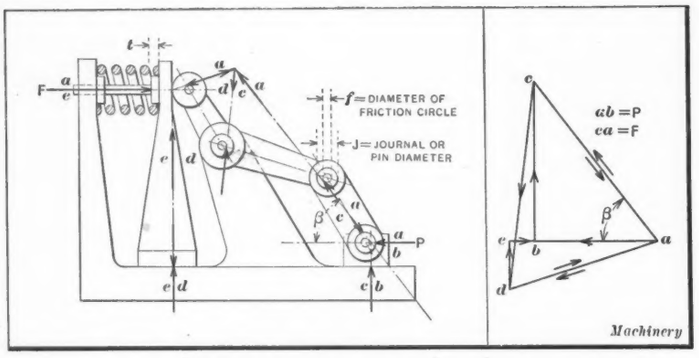


Fig. 4. Toggle Linkage Diagram taking Friction into Account

Fig. 5. Diagram of Forces in Fig. 4

senting the spring scale, may be drawn tangent to the curve *AB* This curve *AB* represents the capacity of the linkage to generate force in terms of *P*, but, due to the resilience of the parts, line *CD* represents the actual force developed. There is then an excess of power for all points except where *AB* and *CD* are tangent. The applied force *P* is seldom, however, steady or constant, as the shifter lever is usually operated with a jerk. There is no resistance during the first part of the movement until the disk clearance and link backlash are taken up; so the energy stored in the moving parts during this part of the stroke is given up as the toggle encounters resistance; as a result, some such force may be generated as is indicated by the line *EG*, Fig. 7. The analysis of this part of the problem thus becomes rather complex. What the designer usually does is to assure himself that he has an adequate lever ratio and then adjusts the clearance until the linkage produces the desired results. In order to proportion the parts he investigates, rather, the force required at the disks in order that the clutch may develop the required torque. This may be done by the aid of the following formulas in which all values are in pounds and inches:

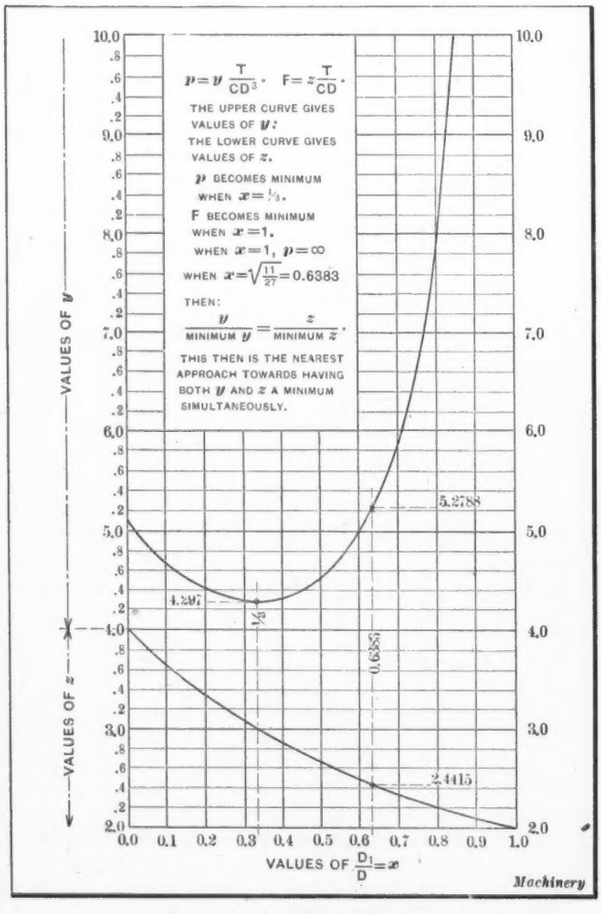

p = y T/CD³ . F = z T/CD .
THE UPPER CURVE GIVES VALUES OF y:
THE LOWER CURVE GIVES VALUES OF z.
p BECOMES MINIMUM WHEN x = 1/3.
F BECOMES MINIMUM WHEN x = 1.
WHEN x = 1, p = ∞
WHEN x = √(11/27) = 0.6383
THEN:
y / MINIMUM y = z / MINIMUM z .
THIS THEN IS THE NEAREST APPROACH TOWARDS HAVING BOTH y AND z A MINIMUM SIMULTANEOUSLY.
VALUES OF y
VALUES OF z
VALUES OF D1/D = x
5.2788
4.2967
2.4415
0.6383
1/3
Machinery

Fig. 6. Curves showing Relation between p and F

D = outside diameter of disks;
D_1 = inside diameter of disks;
F = force pressing disks together;
T = torque or twisting moment developed;
C = coefficient of friction;
n = number of surfaces acting (in Fig. 1, $n = 2$);
p = average unit pressure on disks.

The mean radius at which the tangential frictional forces act is the arithmetical mean radius of the disks, thus:

$$R = \tfrac{1}{4}(D + D_1) \quad (3)$$

Then $$T = nFCR = \tfrac{1}{4} nFC(D + D_1) \quad (4)$$

or $$F = \frac{T}{nCR} = \frac{4T}{nC(D + D_1)} \quad (5)$$

On a basis of the maximum safe value of the average unit pressure p the maximum torque of the clutch will be:

$$T = \frac{n}{16} \pi C p (D^3 + D^2 D_1 - D D_1^2 - D_1^3) \quad (6)$$

On page 292 of the December, 1910, number of MACHINERY, from which the curves of Fig. 6 are reproduced, it was shown that, with given values of D, C and T, the average unit pressure p becomes a minimum when $D_1 = 1/3\,D$. It was also shown that force F decreases with an increase of D_1, becoming, in theory, a minimum when $D_1 = D$. If it is equally desirable to have both p and F at their minimum values, a proposition which is impossible of attainment, the ideal compromise is to make $D_1 = 0.64\,D$, approximately. The formulas for p and F to be used in connection with the factors y and z from the curves, when applied to a clutch having more than one friction surface, are:

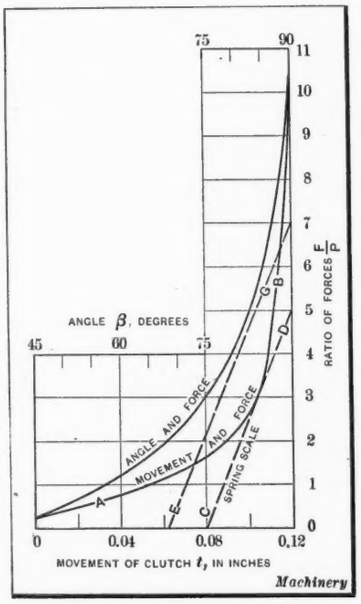


Fig. 7. Force developed by Toggle Linkage

$$p = \frac{yt}{nCD^3} \quad (7)$$

and $$F = \frac{zT}{nCD} \quad (8)$$

The coefficient of friction varies with the materials used and the condition of lubrication, but may be taken about as follows:

Cast iron on cast iron, dry	about 0.20
Cast iron on cast iron, greasy	about 0.16
Cast iron on cast iron, oily	about 0.10
Cast iron on leather, dry	about 0.30
Cast iron on leather, greasy	about 0.25
Cast iron on fibrous liners	0.25 to 0.30
Cast iron on cast iron with cork inserts	about 0.34

In the foregoing the writer's object is to point out methods of analysis rather than the solution of the specific case submitted.

* * *

The Bureau of Mines has prepared specifications for Federal purchases of gasoline in the District of Columbia, according to which the color, which must be water white, is tested by inspection of a column in a four-ounce sample bottle. There must also be a total absence of acidity, which is tested by thoroughly shaking 10 cubic centimeters of gasoline with 5 cubic centimeters of distilled water. The mixture must not color blue litmus paper pink.

NEW MACHINERY AND TOOLS
THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

FAY AUTOMATIC FOR RING BEVEL GEARS

This machine is a special modification of the Fay automatic lathe, adapted for machining ring bevel gears for automobile transmissions. A feature of the machine that enables it to attain high rates of production is that the finishing tools follow directly after the roughing tools, so that no time is lost in bringing them into action. The mechanism is extremely simple and of compact design, so that the amount of floor space required is relatively small.

The Jones & Lamson Machine Co., Springfield, Vt., has developed a highly specialized modification of the Fay automatic lathe for machining the large ring bevel gears in the rear axle drive of automobiles and trucks. The design of this machine confines it to the machining of the bevel face and ends and other incidental operations. By thus confining the work, it has been possible to build a machine that is exceptionally well adapted for this particular operation. Fig. 1 shows the front side of the machine, Fig. 2 the back side, Fig. 3 the gear drive headstock with cover removed, and Fig. 4 a typical tool set-up.

Reference may first be made to Fig. 4 in order to get an idea of the operations for which the machine is designed. The front tool-holder moves on an angle, as shown by the arrow, for finishing the bevel on the outer and inner ends. Tool *A* roughs the outside diameter; tool *B*, immediately following in one continuous motion, finishes it; while tool *C* machines the inside end. The rear tool-holder, moving in the direction of the arrow as shown, carries tool *D*, which roughs the bevel face of the blank. Tool *E*, which follows immediately after, finishes it, and tool *F*, in the same continuous motion, rounds the corner at the back side of the blank. It will be noticed that the front and back faces, and the bore by which the blank is held, have been machined by previous operations on the turret lathe.

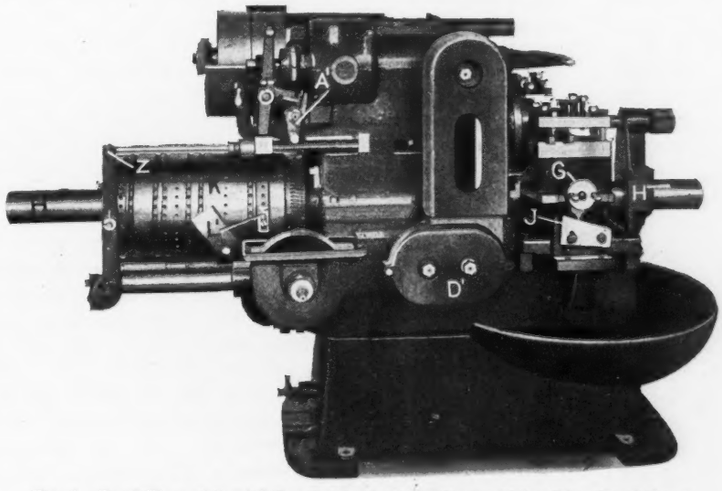


Fig. 1. Front View of Special Fay Automatic Lathe for machining Ring Bevel Gears

Going back again to the description of the machine on which this work is done, at *G* in Fig. 1 is shown the front tool carriage. This carries the tools *A*, *B* and *C*, Fig. 4, and is mounted on bar *H*, which has an endwise motion; the bar and tool-holder together are rocked in the journals of the bar by means of the follower on the under side of the toolpost, which rests on bevel former *J*. This former may be adjusted to any angle required to meet the desired angle for the bevel on the ends of the teeth. The longitudinal movement of bar *H*, by means of which tool-holder *G* and the tools mounted thereon are fed along the work, is effected by cams on the inside of drum *K* operating on a cam roll fastened to a carrier clamped to bar *H* on the inside of the drum.

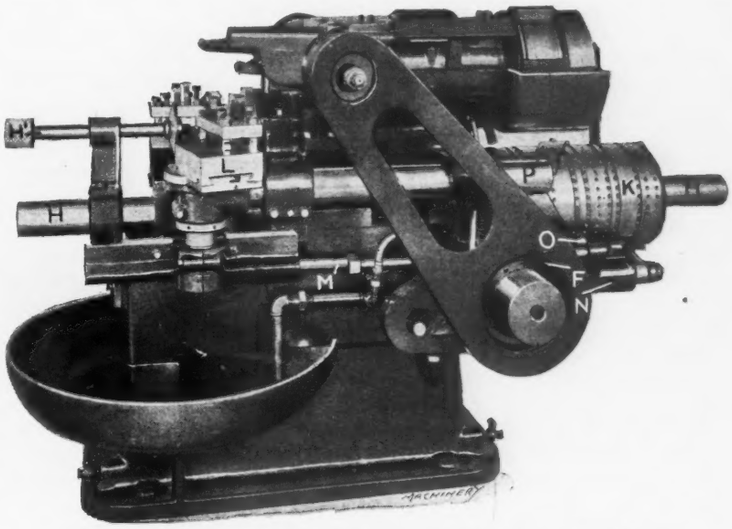


Fig. 2. Opposite Side of Special Fay Automatic Lathe for Ring Bevel Gears

On the rear side of the machine, shown in Fig. 2, is seen the rear tool-holder *L*, which carries the tools *D*, *E* and *F*, Fig. 4. This is a compound rest operated by a strongly constructed rack, gear and pinion device, the pinion shaft extending up through the center of the angular adjustment of the rest. It carries at its lower end a gear meshing with rack *M*, which is, in turn, connected with the cam slide *N* and cam roll *O*, operated by outside cams, of which one is shown at *P* on the drum. The compound rest carrying tool-block *L* can be adjusted to any angle to turn anything from a cylinder to a straight face or even an internal bevel, and will, of course, turn the faces of the gears absolutely straight, so that they can be held properly in the jigs largely used in hardening to prevent distortion.

The movements of both the front and the rear cross-slide are thus seen to be controlled by cams on drum *K*. This drum has a slow motion for feed and a fast motion for idle movements, driven as will be later described, and automatically shifted by adjustable dogs, of which one is shown at *L'* in Fig. 1. The drive of the machine is best shown in Fig. 3, where the headstock is shown with the cover removed. The drive is either from a motor mounted on the headstock, or through the main lineshaft direct to tight and loose pulleys at *Q*. By mounting the tight and loose pulley directly on the drive shaft, it is placed where it can be properly oiled and taken care of, and at the same time the drive is greatly simplified. The drive shaft on which pulleys *Q* are mounted carries a triple sliding gear *R*, shifted by a fork controlled by handle *S*. This sliding gear is set to give any one of the range of three available speeds, depending on the size of ring bevel

gear being machined, hardness of the material, etc. In the three different positions it meshes with the three corresponding gears on intermediate shaft *T*; the gears on this shaft, in turn, drive the third shaft *U* either through slow-speed ratchet gear *V*, intermediate clutch gear *X* or the fast-speed gear *W*. This speed change is under automatic control of the machine by means of a clutch collar and speed change lever *Z* shown in Fig. 1.

Lever *Z* is operated by dogs on the drum, which throw the clutch collar either to its intermediate or extreme right or left position, as may be required at any point in the machining of work. In the intermediate position the drive is through silent ratchet gear *V*. This gives a very slow speed used when the cutting tools are below the scale on hard forgings. The clutch collar is next thrown to the right, giving the intermediate speed through clutch gear *X* used for roughing. When the finishing tools come into play the clutch collar is thrown to the extreme left, bringing the drive through gear *W* and giving a high speed for finishing. The spring release mechanism shown at *A'* in Fig. 1 is used in snapping the gears through the neutral position, in getting from the intermediate to the high speed when changing from roughing to finishing speed.

All the gears of this drive are of hardened steel and run in oil. Pinion *B'* on the third shaft (Fig. 3) meshes with spindle gear *C'*. This spindle gear runs in a bath of oil, which it carries up to a scraper, feeding it into the upper reservoir in which the transmission gears revolve. This reservoir, in turn, drains back through the main bearings of the spindle into the lower reservoir, where the spindle gear *C'* again picks it up and returns it over its course, thus giving continuous lubrication. The geared headstock will thus be seen to give nine spindle speeds without change of drive pulley speed, and these speeds are so arranged that there are three groups of three each in the headstock, operated by hand for any one of the three groups, and any one of the three speeds in that group is obtained automatically at any required point in the operation.

Cam drum *K* is driven by a worm-shaft connected through change mechanism at *D'* in Fig. 1, and a belt with a slow-speed driving pulley *E'* in Fig. 3. This, it will be noted, is connected with the third shaft, which receives all the speed variations of the geared head drive. The change-gears may thus be set for any feed in revolutions per inch, irrespective of the spindle speed. The fast motion is through a clutch pulley *F*, shown at the back of the machine in Fig. 2. This is belted to fast-motion drive pulley *G'* in Fig. 3. Pulley *G'*, being geared for a main driving shaft, runs at constant speed, so that fast motions of the cam drum are always at high speed, irrespective of whether the spindle is running slow or fast.

This arrangement, together with the fact that no time is required for turning turrets, or other similar idle operations, reduces the idle moments of the machine to practically nothing. Finishing tools, as shown in Fig. 4, follow immediately after the roughing tools, so that no time is lost in bringing them into action. Another interesting provision possible with some

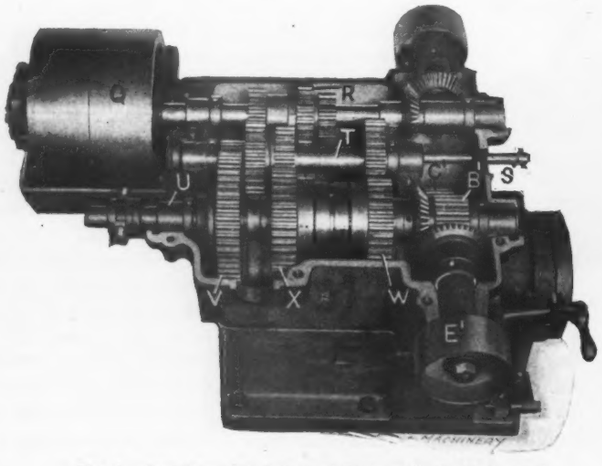


Fig. 3. Gear-driven Headstock of Lathe with Cover removed

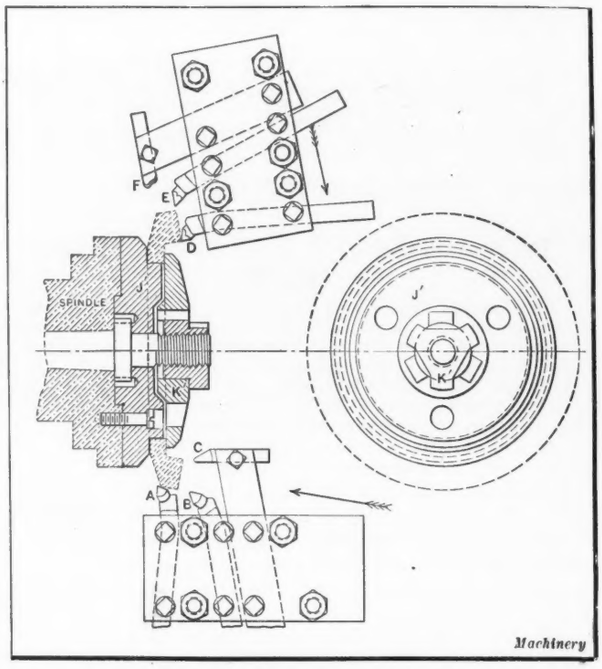


Fig. 4. Typical Tool Set-up for Special Fay Automatic Lathe for Ring Bevel Gears

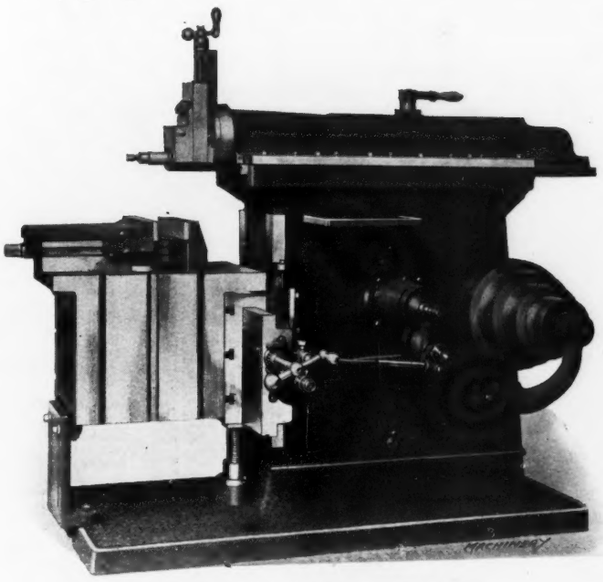
designs of ring gears is shown clearly in Fig. 2. It consists of the wrench shaft *H'*, carrying on its inner end the flange plate by means of which the ring gear is held onto the fixture on the end of the spindle. By this means the flange is always in place on the machine, and it is not necessary to pick it off and set it on a bench with other outside pieces. It only remains to clamp it and unclamp it as the work is put in and removed, leaving the hands of the operator free for handling work.

With other designs of ring gears it is better to use the arrangement shown in Fig. 4, where the flange *J'* is clamped up against the work by nut *K'* with interrupted holding lugs, which are such that when the nut is released the flange may be drawn off past the lugs through its clearance slots, without requiring the nuts to be entirely screwed off and on. Either one of these clamps gives great rapidity in loading and unloading. The compactness of this machine is seen at a glance, as well as the large amount of chip room and the ease of access to the work and tools. A chip guard is provided that comes up high around the machine, giving a large reservoir space for the oil and at the same time permitting the oil to be drained into the base of the machine. The oil-pump has large capacity through direct, unobstructed piping, giving a full flow of cutting compound on the work.

The advantages claimed for this machine are: (1) Continuous production at exactly the right feeds and speeds required for the most efficient cutting without any lost time required for idle movements. (2) Compactness of mechanism for the amount of output per machine, reducing the factory space required for a given production. (3) Extreme simplicity of mechanism and the confining of the machine to single-spindle units, so that in the event of any slight disarrangement in the mechanism but a small part of the production is held up. (4) The low capital cost for a given output, made possible first by high productivity and the low cost of each unit. (5) Low labor cost, owing to quick change of work possible; high speeds and feeds; and quick change from one job to another, the camming being permanent.

HOLLINGWORTH SHAPER

One of the recent products of the Hollingworth Machine Tool Co., Covington, Ky., is a 24-inch triple-geared crank shaper, which is illustrated and described herewith. To provide for taking exceptionally heavy cuts, the machine has been designed on the triple-geared principle, with a quick return stroke. The walls of the column, ram and base have also been



Hollingworth 24-inch Triple-geared Crank Shaper

heavily constructed and strongly ribbed, so that ample strength is provided for severe classes of service. The length of stroke can be adjusted while the machine is at rest or in motion, thereby avoiding the necessity of stopping the machine for this purpose. The device for changing the stroke is so arranged that it is possible to make changes while the machine is actually at work. The ram can be quickly adjusted to suit the position of the work, and a short stroke can be taken at any point.

All flat bearings are hand-scraped to surface plates and all wearing surfaces on the machine are provided with gibs for making fine adjustments. The shaft bearings are furnished with bronze bushings that can be readily removed or replaced when necessary. A system of oilers carry lubricant to the shaft bearings; and the same type of oiling device is used throughout the machine. The arm for supporting the pulley shaft provides support at the outer end of this shaft, thereby giving it three bearings. All gears in the machine are cut from solid blanks. The cross-rail is designed with wide bearings, which are carefully scraped to surface plates. The tool-head may be instantly set and rigidly held at any angle, by means of a swivel bolt in the head, which is graduated and may be swiveled to any angle up to 90 degrees. A micrometer dial for the feed movement is graduated to 0.001 inch.

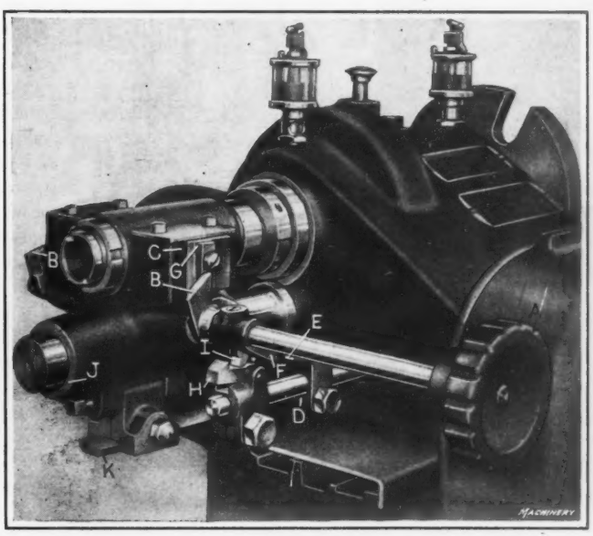
The table is slotted on the top and at both sides, and it may be readily removed to enable work to be bolted to the slotted saddle by which the table is carried. The top of the table measures 16 by 23 inches, and by having it slotted for the entire length, provision is made for a liberal sized clamping surface. The base of the vise is graduated to 360 degrees and the upper jaw is held in position by means of steel gibs. The steel faced jaws for the vise are 2½ inches deep by 12½ inches long, and the vise opens 12½ inches. The elevating screw is of the telescopic type and has a ball-bearing washer below the table, which insures easy operation. The cross-feed mechanism is of simple design and the rate of feed can be varied while the machine is in motion. A lifting and turning pawl is used for engaging or disengaging the feed, which is automatic in either direction. A micrometer dial on the cross-feed screw is graduated to 0.002 inch.

The table support furnished with each machine is of simple design, and there is nothing to get out of order. This support can be quickly adjusted by means of a screw, and is always under the cut. The countershaft has two friction pulleys, 12 by 4 inches in size, and should run 175 and 325 revolutions per minute. In this way two changes of speed are available for each step of the cone pulley. The total range of speeds is 7, 11, 17 and 28 strokes per minute for the slow-speed countershaft pulley and 12½, 20½, 33 and 58 strokes per minute for the high-speed countershaft pulley. The principal dimensions of the machine are as follows: actual length of stroke, 24½ inches; maximum automatic cross-feed, 26 inches; maximum vertical adjustment of table, 14½ inches; maximum feed of tool-block, 8 inches; ratio of gearing, 13 to 1; and width of double machine belt, 3¼ inches.

PORTER-CABLE LATHE SCREW-CUTTING ATTACHMENT

The Porter-Cable Machine Co., Syracuse, N. Y., has added a screw-cutting attachment to the line of labor-saving devices developed for use on its manufacturing lathe. This screw-cutting attachment will handle threading operations on work up to 2½ inches in length, and there are a number of features incorporated in its design that provide for speed of operation and accuracy of the work. All gearing has been eliminated between the spindle and carriage, the latter being actuated directly by the lead-screw through a traveler *J* connected to the carriage by the dovetailed pull-rod *K*. The lead-screw is made in the form of an external threaded sleeve and mounted on an extension at the rear end of the lathe spindle, this extension being accurately screwed onto the threaded end of the spindle in the same manner as the lever chuck closing attachment used on this lathe. Lead-screws and nuts of standard pitches can be furnished to cover U. S. standard threads from ¼ to 1 inch, and also A. L. A. M. and pipe threads, as it is necessary to use a lead-screw and nut of the same pitch as the thread to be cut. These parts are designed to be readily interchangeable and they are comparatively inexpensive.

The set-up and operation of the screw-cutting attachment is as follows: The lathe carriage is located in the position that it should occupy when starting the cut, and the right-hand carriage stop is brought up to it and secured in place. Traveler *J* should be located adjacent to the headstock and secured to pull-rod *K*, which is attached to the carriage by means of a grip screw. While the carriage is in this position knob *A* is turned to the left to bring two arms *B* into the position shown. This simultaneously engages two segmental jaw-like nuts with the lead-screw, one of these nuts being shown at *C*, while the other is diametrically opposite on the lead-screw. Stop *D* should next be positioned and secured so that finger *E* will contact with finger *F*. When the machine is in operation this arrangement enables the operator, when starting a cut, to turn knob *A* quickly to the left until finger *F* stops against finger *E*, which makes it impossible to turn knob *A* too far and insures the proper positioning of arms *B* in order to throw the nuts into engagement with the screw. The knob should next be turned a sufficient amount to the right to allow the nuts to be disengaged from the screw and the carriage to be run forward by hand to the position it will assume at the end of the cut. The knob is turned to the right as far as it will go, or until the square corner of arm *B*



Screw-cutting Attachment for Lathe built by Porter-Cable Machine Co.

strikes the left-hand side of block *G*, and trip latch *H* is then secured so that it engages with trip finger *I*.

The work is now set up and the cycle of operations is as follows: (1) Start lathe. (2) Move carriage by hand toward tailstock until it comes to stop. This brings the tool into the starting position. (3) Feed tool to depth and turn knob *A* quickly to left as far as it will go, which throws nuts into engagement with lead-screw and moves carriage forward. The carriage travels forward until the nuts are automatically disengaged by finger *I* engaging with latch *H*, which rotates arms *B* to the left until the square corners on the arms drop off the square corners on the thrust blocks. This arrangement insures that the carriage will stop accurately in any place at the end of each cut. (4) Withdraw tool, return carriage by hand to starting position and continue cycle of operations until thread is finished. The operation of this thread-cutting attachment is so simple and positive that with a suitable stop on the cross-slide of the lathe, which would limit the total depth of cut, it is claimed that the operator could quickly cut a thread with his eyes shut. The accuracy of the work produced depends only upon the accuracy of the lead-screw, as the work will be an exact duplicate of the lead-screw.

WEIGEL DRILLING MACHINE

The Weigel Machine Tool Co., Peru, Ind., is now building a 25-inch vertical drilling machine, two views of which are shown in Figs. 1 and 2. This machine is built in two grades, one being furnished with babbitted bearings and the other with Damascus bronze bearings. The base is ribbed underneath to provide stiffness, and it has an oil-pan of ample size extending entirely around the outer edge. Four T-slots are milled in the base for clamping work. The column is of tubular section and provides ample bearings for the table arm and sliding head. The table is designed with a heavy face to prevent springing by clamps holding the work, and it is furnished with the usual T-slots for clamping work in place. The table arm is raised and lowered by a rack and pinion actuated through a worm and worm-gear. The bore for the hub on the table is made large enough to enable a compound table to be used without requiring any change to be made. This hole is bored to a plug gage so that a compound table can be substituted for the standard table at any time.

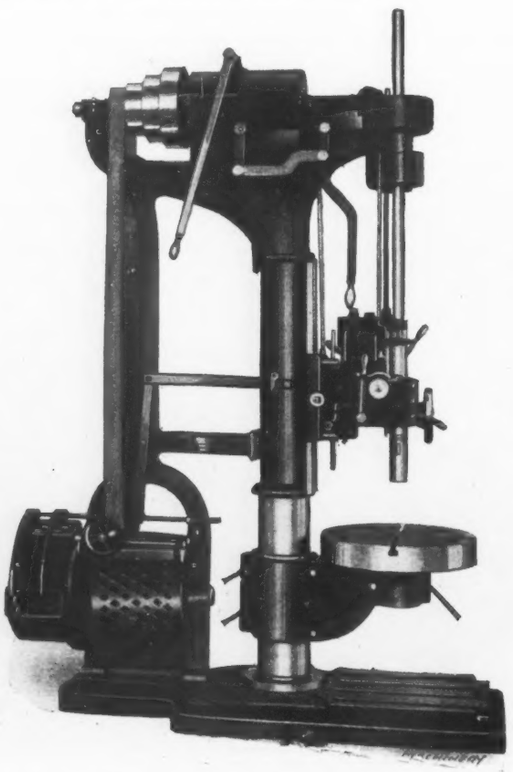


Fig. 1. Weigel 25-inch Vertical Drilling Machine

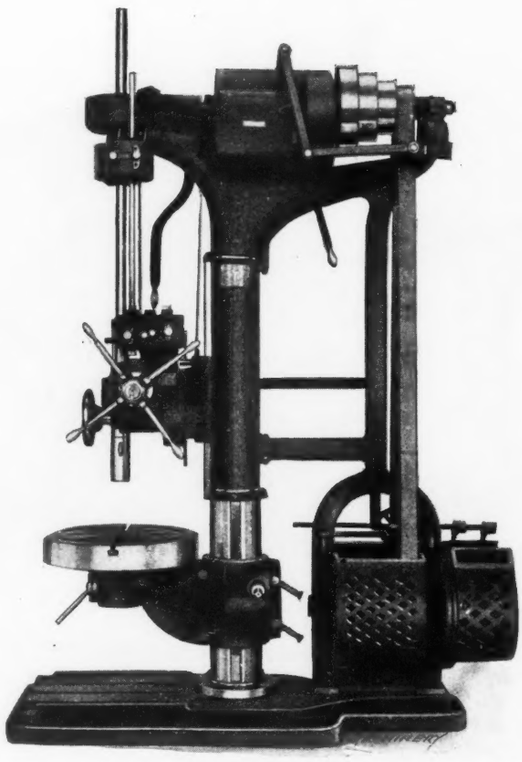


Fig. 2. Opposite Side of Weigel Vertical Drilling Machine shown in Fig. 1

This machine is furnished with either plain sliding back-gears or the Weigel improved friction type of back-gears. The friction back-gears are positive in action and easily operated by a lever conveniently located at the front of the machine. All gears are entirely covered and run in an oil-tight case, which insures perfect lubrication. Eight rates of feed are provided for each spindle speed, the feed changes being obtained by means of sliding gears. Any feed is easily and quickly obtained by convenient levers, the rate being indicated by a plate attached to the machine. For the friction quick-return, the operating levers are placed in the form of a pilot wheel consisting of four levers, any one of which engages or disengages the feed at will. An automatic stop which is positive in its action can be set to throw out the feed at any predetermined depth. The worm operating the quick-return shaft is triple-threaded.

This machine can be furnished with the Weigel improved friction tapping attachment, which is placed directly on the spindle and has a reverse ratio of 2 to 1 for backing out the tap. A long driving key is provided on the spindle to prevent cramping on either the forward or reverse motion. Provision is made for disengaging the tapping attachment when it is not required. Provision is also made for equipping this drilling machine for either direct-geared motor drive or the application of motor drive with transmission through a belt. This machine is said to comply with all state laws governing the provision of means for guarding against accidents to operators. All gearing in the head is entirely covered by housings cast integral with the head, as well as the back-gears on the yoke and gearing on the table arm. The lower cone pulley is entirely covered by a cast housing, and the tight and loose pulleys have an adjustable guard. A belt shifter is furnished on all machines to provide for shifting the belt on the cone pulleys, and as the operator does not have to shift the belt by hand, he will be more likely to change the speed in order to obtain that which is required for the work he is doing.

The principal dimensions of this machine are as follows: extreme height with spindle extended, 9 feet, 9½ inches; height to top of drill, 7 feet, 11 inches; distance from base to spindle, 47½ inches; distance from table to spindle, 30½ inches; capacity, for drilling to center of 25⅝-inch circle; traverse of table on column, 13½ inches; travel of head on column, 21 inches; diameter of table, 22 inches; diameter of column, 7½ inches; diameter of spindle above sleeve, 1 9/16

inch; diameter of spindle in sleeve, 1 11/16 inch; diameter of sleeve, 2⅝ inches; taper of hole in spindle, No. 4 Morse; ratio of back-gears, 2.5 to 1; available rates of feed per spindle revolution, 0.0040, 0.0054, 0.0081, 0.0108, 0.0162, 0.0216, 0.0224 and 0.0432; size of cone pulley steps, 6, 8, 10 and 12 inches in diameter by 2¾ inches face width; size of tight and loose pulleys, 12 inches in diameter by 3¼ inches face width; speed of tight and loose pulleys, 500 R.P.M.; available spindle speeds through open belt, 100, 160, 250 and 400 R.P.M.; and available spindle speeds through back-gears, 15, 25, 39 and 62 R.P.M.

CINCINNATI-BICKFORD MOTOR-DRIVEN RADIAL DRILLING MACHINES

The radial drilling machines manufactured by the Cincinnati Bickford Tool Co., Oakley, Cincinnati, Ohio, are well known to readers of MACHINERY, but the accompanying illustrations show some recent developments in variable-speed motor drive. These radial drilling machines are furnished with four types of drive, as follows: cone pulley; gear-box; motor drive through gear-box; and variable-speed motor drive. In Figs. 1 and 2 are shown two highly developed forms of variable-speed motor drive.

Fig. 1 shows a Cincinnati-Bickford plain radial drilling machine with a plain table, which is made in four-, five- and six-foot sizes. This machine is equipped with an air column binder and cutting lubricant outfit; it is driven by a 3 to 1 variable-speed motor mounted on the arm and geared direct to the arm-shaft. The controller is placed on the head. The arm is elevated by a constant-speed, reversing, compound-wound motor mounted on top of the column and controlled by a reversing switch and dynamic brake resistance. The switch is operated by a square shaft controlled by the Cincinnati Bickford Tool Co.'s patented interlocking device; and a revolving connection in the base of the column permits wires to enter at this point and run up through the center of the column to the top.

Fig. 2 shows one of the Cincinnati-Bickford radial drilling machines, which is built in four,- five- and six-foot sizes. This machine is equipped with a plain table, cutting lubricant outfit and air column binder. It is equipped with a Reliance adjustable-speed motor having a starter attached. There is also a form R. C. small motor for speed adjustment attached to the large motor and remote speed control by a push-button mounted on the head of the machine.

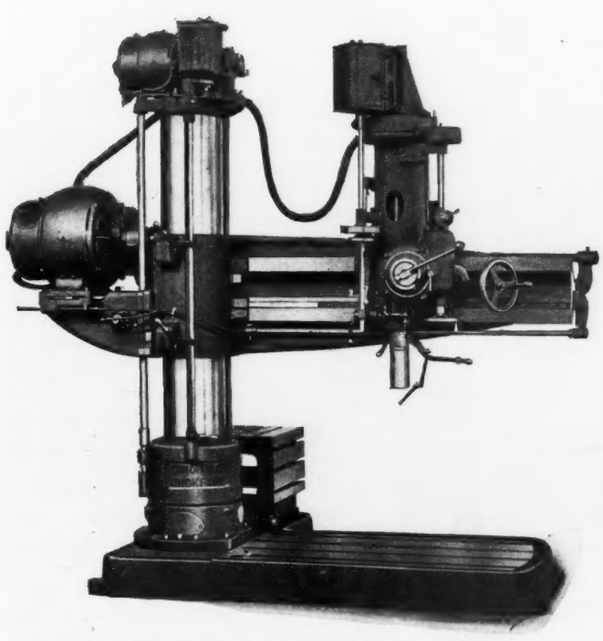


Fig. 1. Cincinnati-Bickford Plain Radial Drilling Machine with 3 to 1 Variable-speed Motor mounted on Arm

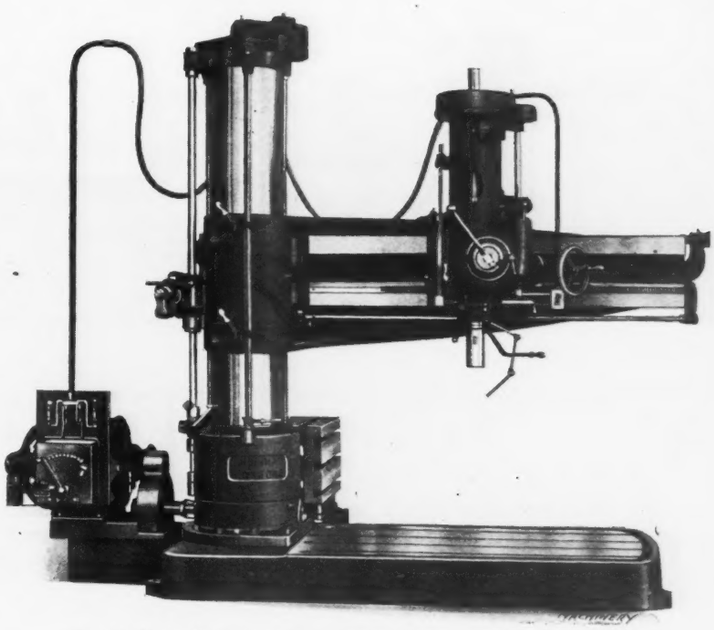


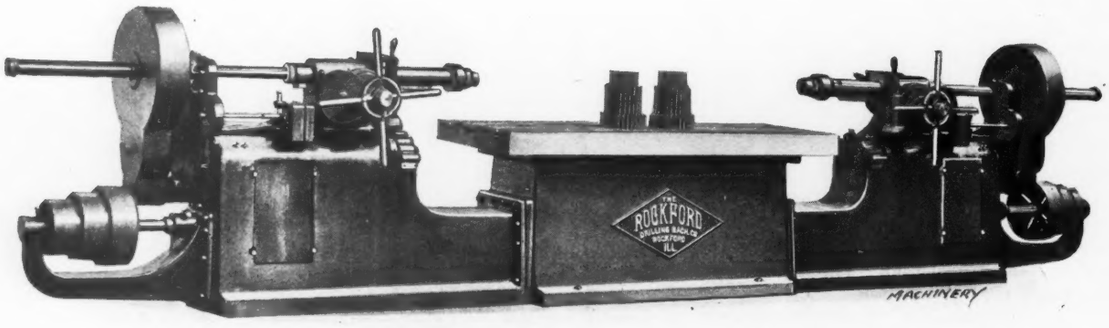
Fig. 2. Cincinnati-Bickford Plain Radial Drilling Machine with Reliance Adjustable Motor mounted on Base

ROCKFORD BORING AND DRILLING MACHINE

The Rockford Drilling Machine Co., Rockford, Ill., is now building a heavy-duty horizontal boring and drilling machine, which is especially adapted for use in manufacturing parts in large quantities. This is a single-purpose machine, and is built to customers' specifications in regard to spindle height above table, length of table and distance between spindle ends. The capacity is for driving high-speed drills up to 2½ inches in diameter in steel and for boring holes up to 6 inches in diameter in steel. Several types of machines are built, which include a single-spindle machine, a double-spindle machine with spindles opposed (as shown in the accompanying illustration), a double-spindle machine with the spindles at right angles, and machines with three or four spindles. The bearings are made of phosphor-bronze and are interchangeable. Drive is through a three-step cone pulley, which carries a 4-inch belt, and each spindle has entirely separate speed control, being furnished with its own tight and loose pulley countershaft. All bearings in the countershaft are bronze bushed and equipped with oilers. The speed changes, beyond those furnished by the three-step cone pulley, are obtained by means of interchangeable pick-off gears, and attention is called to the fact that no bevel gears are used in the drive. All gears are of large pitch and wide face to provide ample strength.

There are four available rates of feed, which are taken from the spindle, and any of these four changes is instantly obtainable. The spindle is forged from high carbon steel and fitted with two special ball-thrust bearings. The spindle nose is bored No. 5 Morse taper, and is slotted across the end to provide for driving heavy boring and facing heads. Hand traverse of the spindle is obtained by means of a star lever, which works through reduction gears, giving a powerful hand feed. This machine is especially adapted for the performance of repetition work, such as boring crank-cases, transmission cases and rear axles for automobiles, headstocks and tailstocks for lathes, core drilling, etc. The design is such that the machine lends itself readily to the application of multiple-spindle heads for machining from two to ten holes at one time. On multiple-spindle machines, two or more pieces can be operated upon at the same time, which is the means of conserving floor space and economizing in operator's time.

The principal dimensions of this machine are as follows: capacity for drilling in steel, up to 2½ inches; distance from

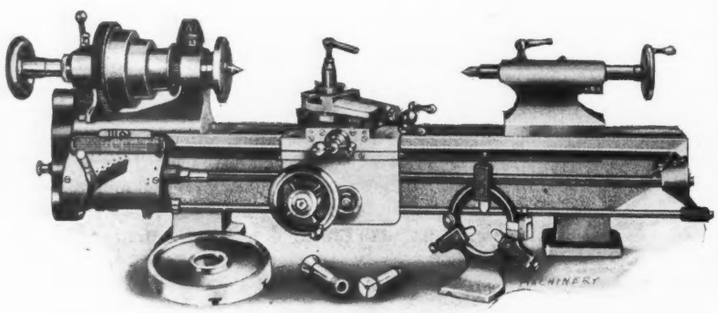


Heavy-duty Horizontal Boring and Drilling Machine built by Rockford Drilling Machine Co.

spindle to table, distance between spindle ends and length of table, made to suit requirements; length of feed, 20 inches; diameter of spindle sleeve, 3⅜ inches; smallest diameter of spindle, 2 inches; taper of spindle hole, No. 5 Morse; width of hardened nickel steel feed rack, 2 inches; diameter of spindle driving gear, 18 inches; size of regular table, 24 by 72 inches; height of table from floor, 30 inches; available rates of feed, 0.010, 0.015, 0.022 and 0.030 inch per spindle revolution; size of driving pulley on countershafting, 14 inches diameter by 6¼ inches face width; speed of countershaft, 500 revolutions per minute; and ratio between drive and spindle, 5 to 1.

WADE PRECISION LATHE

In introducing this toolmaker's precision lathe, attention is called to the fact that it is not a revolutionary product. The design follows established lines that have proved satisfactory in various classes of service. The claims made for the present machine are that it is of sturdy construction, accurately finished and built along lines that will provide durability for the machine and accuracy of the work. This lathe is adapted for handling all kinds of tool and scientific instrument work, and for use in the manufacture of fine gun parts and similar products. The head swings 8½ inches and the lathe is 45 inches long, giving ample room for handling work up to 24 inches in length between centers.



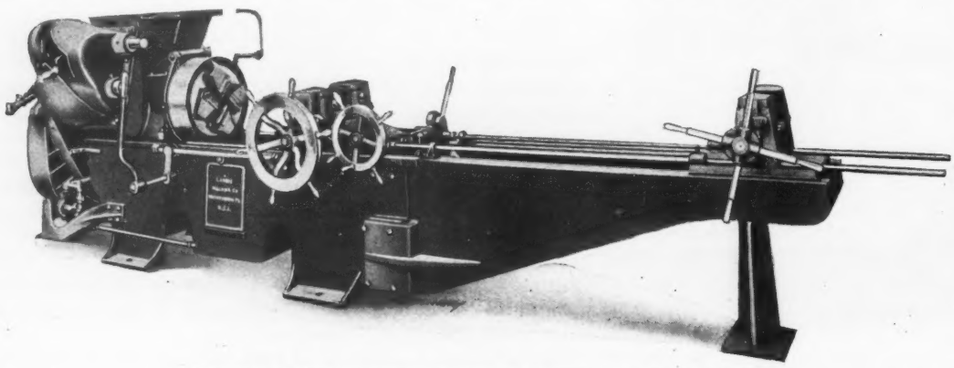
Toolmaker's Precision Lathe built by Walter H. Wade

The bed is in the shape of a hollow square with cross-ribs, giving ample strength and rigidity. The ways are placed forward directly over the supporting sides of the bed, which affords a solid construction and avoids forming a pocket in which dirt and chips are likely to collect. The head is back-geared and the spindle and its bearings are of the cone type, the spindle being made of tool steel, hardened, ground and lapped and provided with means of adjusting for wear. Provision is made for setting over the tailstock for turning tapered work, and the tailstock spindle has a bearing for the full length of the spindle in any position.

It will be seen that this lathe is provided with a quick-change gear-box, and screw threads of twenty-four different pitches can be cut, covering a range from 12 to 120 per inch. The gears are shifted by three levers, and a feed 2.9 finer than the screw feed is obtained through a feed-rod. The lead-screw is ¾ inch in diameter and has eight threads per inch; it is made of crucible steel and the threads are cut with a master lead-screw. The nut that fits the lead-screw is made of bronze and is of ample length to give the desired durability. All gears in the lathe are made of steel and cut from solid blanks. The spring chucks used on this machine are made of steel, hardened, tempered and ground; these chucks are made in eleven sizes, ranging from 1/8 to 3/4 inch by intervals of 1/16 inch. A two-speed countershaft of the wall type is furnished with each lathe. It has pulleys 6 inches in diameter by 2 inches face width. The cone pulley steps are 6½, 5¼ and 4 inches in diameter by 1¼ inch face width. Three treadles furnished with the countershaft operate the spring shippers. This machine is a recent product of Walter H. Wade, 311 Atlantic Ave., Boston, Mass.

LANDIS THREADING MACHINE

The Landis Machine Co., Waynesboro, Pa., has recently designed and built a machine for a large shipbuilding plant, which is used for threading hollow staybolt tubes. These tubes vary from 6 to 8 feet in length and from 2¾ to 3½ inches in diameter. The machine is equipped with an auxiliary bed, which is attached to the main bed, and this extension bed supports an auxiliary carriage fitted with threaded grips employed in timing the threads on the ends of the tubes and also for supporting the tubes. A lead-screw attachment insures obtaining a high degree of accuracy and a perfect start for the thread; there is also a pitch indicator that shows the correct position for engaging the



Threading Machine for Hollow Staybolt Tubes built by Landis Machine Co.

lead-screw nut. The accompanying illustration shows the machine arranged for drive by an alternating-current, constant-speed motor with a mechanical speed-change box and drive through sprockets and a silent chain. The illustration does not show the motor in position.

In threading hollow staybolt tubes on this machine the method of operation is as follows: One end of all the tubes is threaded by gripping them in the vise of the regular carriage. Then a master tube, which has both ends threaded with threads continuous, is placed in the machine and the chasers are closed down on the threaded portion on one end, *i. e.*, the grooves or serrated surfaces of the chasers are fitted in the threads already cut on the master staytube. Next the outer end of this master tube is gripped with the thread grips in the auxiliary carriage; these grips should be sufficiently loose so that they can adjust themselves endwise with the thread on the master tube. After the master tube has been gripped in the extension carriage, the threaded grips should be secured in the auxiliary carriage vise jaws. Next the lead-screw nut of the main carriage is thrown in and the tube is gripped in the regular vise of the main carriage. The chasers, lead-screw and threads on the staybolt tubes will then all be correctly timed. The master staytube is now removed and the tubes, which have already been threaded on one end, are placed in the threaded grips of the auxiliary carriage, the lead-screw nut being engaged when the pitch indicator on the main carriage shows the correct position for engaging this nut. The operation of threading the other end of all the tubes can then proceed, and the threads on both ends of the tube will be continuous. This machine employs the Landis all-steel rotary die-head and long-life chasers.

DAVID A. WRIGHT SCREW MACHINE

David A. Wright, 568 Washington Blvd., Chicago, Ill., is now manufacturing the No. 1½ hand screw machine shown in Fig. 1. It is equipped with an automatic chuck which has capacity for handling round bars 13/16 inch in diameter, square bars of 19/32 inch, and hexagon bars of 23/32 inch; work up to 6 inches in length can be handled on the machine. This screw machine is heavily constructed to adapt it for operation at high speed, and it has an ample swing and plenty of clearance for the cut-off slide. A special turret operating mechanism has been designed to embody features of simplicity and durability; this mechanism is illustrated in Fig. 2. There

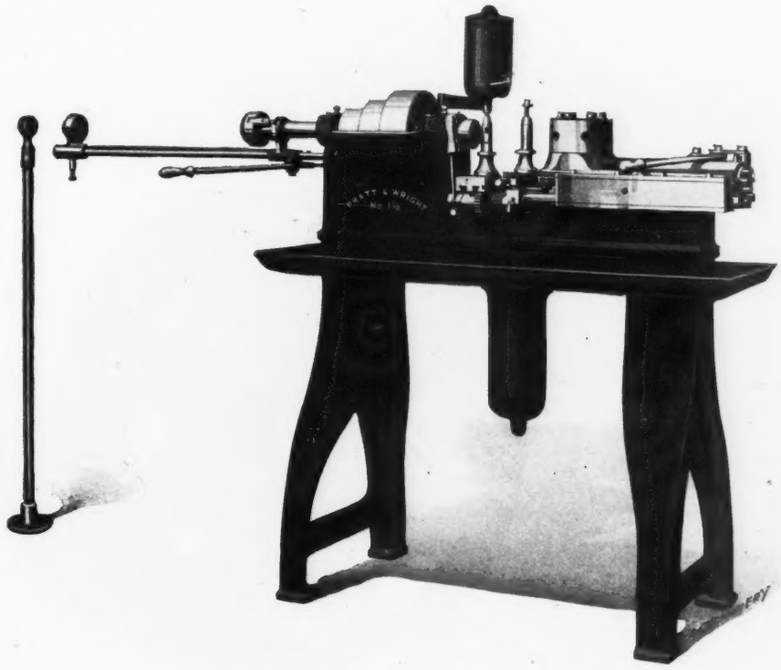


Fig. 1. No. 1½ Hand Screw Machine built by David A. Wright

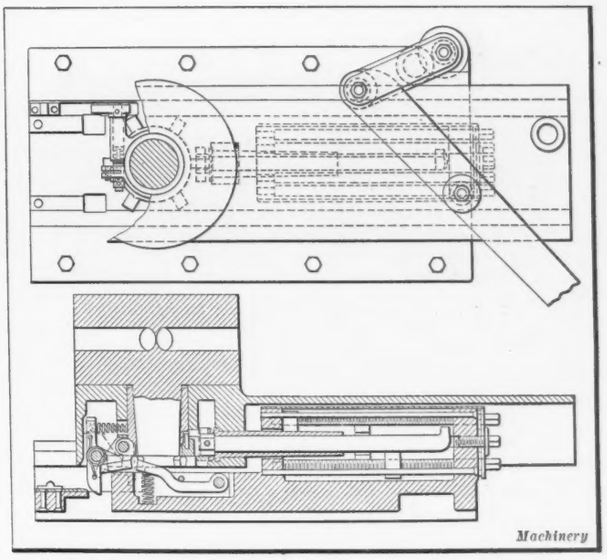


Fig. 2. Plan View and Longitudinal Section of Turret Operating Mechanism

are individual adjustable stops for each of the six positions of the turret, which has an efficient locking mechanism. Rollers are provided on the wire feed dog; and the gage finger automatically revolves, engaging with respective stop-nuts that travel longitudinally on stationary stop-screws Means are provided to compensate for wear of the turret bearing. There is a triple locking feature for the turret, which, in one position, allows the turret to be turned in either direction when only a few tools are employed.

The principal dimensions of this machine are as follows: diameter of hole through chuck plunger, 7/8 inch; diameter of hole through spindle, 1 3/32 inch; diameter of thread in spindle, 2 1/8 inches; capacity for handling threaded work on soft steel, up to 1/2 inch; drilling capacity, up to 3/8 inch; length of work that can be turned, up to 6 inches; maximum distance from end of spindle to face of turret with saddle even with end of bed, 11 inches; swing over bed, 11 1/4 inches; swing over cut-off slide, 6 inches; dimensions of front spindle bearing, 1 3/4 by 3 1/2 inches; dimensions of rear spindle bearing, 1 5/8 by 2 5/8 inches; diameter of round turret, 5 3/4 inches; size of hexagon turret, 5 3/4 inches across flats; diameter of tapped holes in turret face, 3/8 inch; distance from center of turret holes to top of slide, 1 15/16 inch; maximum travel of cross-slide, 6 inches; size of cut-off tools, 7/16 by 1 inch: length of wire feed bar, 33 inches; diameters of cone pulley, 8, 6 1/4 and 4 1/2 inches; width of driving belt, 2 1/2 inches; diameter of countershaft friction pulleys, 10 inches; width of belt, 2 3/4 inches; speed of countershaft, 210 R.P.M.; available spindle speeds, 200, 305 and 500 R.P.M.; power required to drive the machine, one horsepower; floor space occupied, 20 by 54 inches; and weight of machine with countershaft, 750 pounds.

VICTOR FLOATING REAMER-HOLDER

It frequently happens that users of turret machinery experience difficulty in reaming holes true and to size. This is usually due to an error in the reamer shank or to faulty alignment of the turret and spindle of the machine. With the view of overcoming trouble of this kind, the Victor Tool Co., Inc., Waynesboro, Pa., has developed the Sheuman floating

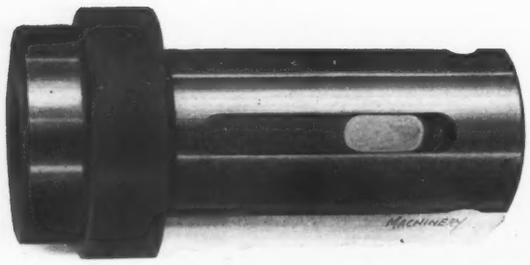


Fig. 1. Victor Floating Reamer-holder for Reamers with Tapered Shanks

reamer-holder; it is stated that this tool has been thoroughly tested in the manufacturer's shops, where it has proved entirely satisfactory. In working out the design of this reamer-holder, care has been taken to simplify its construction as far as possible. The shank of the socket is of smaller diameter than the bore of the socket bushing; and the shoulder of the socket bears on a thrust ball bearing that permits the reamer to adjust itself into perfect alignment with the spindle of the machine, so that it always reams to its actual size and cuts perfectly straight. The pin at the rear serves only to keep the socket from turning in the socket bushing.

It is claimed that when using this tool it is not necessary for the foreman to devote time to setting reamers, as any inexperienced machine operator can set this tool to produce satisfactory work. In times such as the present, when manufacturers are compelled to employ a great deal of unskilled labor, this is an important feature. This reamer-holder is suitable for use on automatic screw machines, turret lathes, horizontal or vertical boring mills, and all other types of turret machines. Holders of this type are made in five stand-

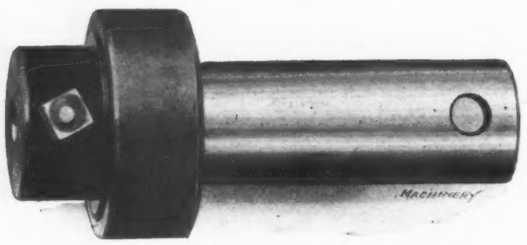


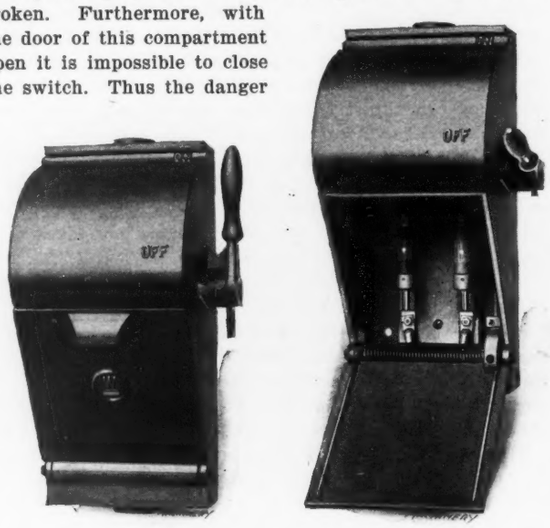
Fig. 2. Victor Floating Reamer-holder for Reamers with Straight Shanks

ard sizes, as follows: size of hole, No. 2 Morse; diameter of socket bushing, 1¼ inch; size of hole, No. 3 Morse, diameter of socket bushing, 1½ inch; size of hole, No. 4 Morse, diameter of socket bushing, 2 inches; size of hole, ½ inch diameter, straight, diameter of socket bushing, 1¼ inch; size of hole, ⅞ inch diameter, straight, diameter of socket bushing, 1½ inch. Special holders can be made to suit any size of reamer shank, either straight or tapered, and the socket bushing can be made to fit any turret.

WESTINGHOUSE "SAFETY FIRST" SWITCH

In steel mills, factories and similar places employing men with practically no knowledge of electricity and its attendant risks, an absolutely safe switch has become a necessity. The really safe switch is one so constructed that all live parts are totally enclosed and inaccessible. Means should also be provided for preventing operation by unauthorized persons. The switch shown, which has been brought out by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., is typical of the real safety switch. Its use assures the maximum protection implied in the word "safety." The complete device consists of an ordinary single-throw knife switch and enclosed fuse-holders mounted in an exceptionally strong cast-iron box, with an operating handle outside the housing. The box is designed for conduit connection and has a partition separating the switch blades from the fuse-holders.

The upper or switch compartment can be opened only by removing two machine screws. This compartment should never be opened except when making connections, or in case of inspection or repairs, as the switch is opened and closed by the operating handle, from the outside, through a shaft and lever inside the box. The lower or fuse compartment, containing the fuses and fuse-holders, is the only part of the switch that need be opened, and then only to replace blown fuses. The door of this compartment is so interlocked with the switch by a vertically acting push-rod engaging a boss on the fuse-compartment door that it can be opened only when the operating handle is in the off position and the circuit broken. Furthermore, with the door of this compartment open it is impossible to close the switch. Thus the danger



Figs. 1 and 2. Westinghouse "Safety First" Switch with Cover Closed and Open

of a live line is eliminated. The operating handle can also be locked with the switch in the open position, preventing tampering by unauthorized persons.

AMERICAN STEEL SPLIT PULLEY

Every engineer knows that there are certain drives requiring the use of stronger pulleys than those used for average classes of service. To meet such conditions, the American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa., has developed a special heavy-duty type of steel split pulley, which is shown in the accompanying illustration. Pulleys of this type are made in sizes ranging from 36 to 84 inches in diameter, inclusive, with either a 6-inch or 8½-inch bore. This type of pulley is particularly suited for driving drop-hammers and other machinery having a heavy intermittent load; they also find application in driving air compressors, rock break-

Steel Split Pulley made by American Pulley Co.

ers, crushing rolls, centrifugal pumps, Beater engines and Jordan engines in paper mills. In fact, they are used for any severe service where a special cast-iron pulley would otherwise be required.

T. R. ALMOND MICROMETERS

The T. R. Almond Mfg. Co., 2 Maple Ave., Ashburnham, Mass., has recently added to its products three types of micrometers, which are shown in Figs. 1, 2 and 3. Each of these is made in two styles for English measurements and metric

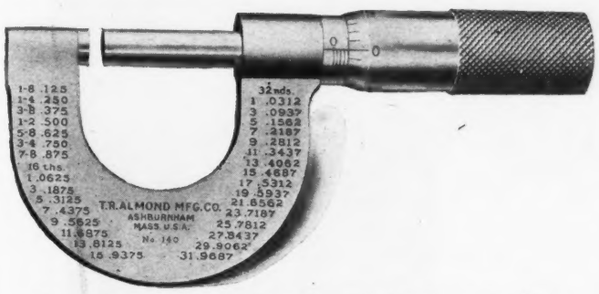


Fig. 1. Almond No. 140 Micrometer for 0 to 1 Inch, and No. 141 for 0 to 25 Millimeters

measurements. It will be apparent from the illustrations that the design of these tools follows quite closely along the lines of standard practice. It is claimed that they are highly accurate, and the manufacturers request that in testing the accuracy of these micrometers Johansson Swedish gages shall be used.

Fig. 1 shows a micrometer which is made in a No. 140 style for English measurements from 0 to 1 inch. Two types of this style of micrometer are made to read to 0.001 and 0.0001 inch, respectively. This micrometer is also made in a No. 141 style for metric measurements from 0 to 25 millimeters by 0.01 millimeter. These micrometers are furnished with neither a ratchet stop nor lock-nut. It will be seen from the illustration that a table of decimal equivalents is furnished on the frame of the micrometer.

Fig. 2 shows another Almond micrometer, which is also made in two styles for English and metric measurements. The style known as No. 139 makes English measurements, and this style of micrometer is made in two sizes for dimensions from 1 to 2 inches and from 2 to 3 inches. Both sizes are made in two types to read to 0.001 and to 0.0001 inch. This micrometer is also made in a No. 142 style for metric measurements, and two sizes are made for measuring work from 25 to 50 millimeters and from 50 to 75 millimeters. Each size of micrometer reads to 0.010 millimeter, and this micrometer also has neither a ratchet stop nor lock-nut.

Fig. 3 shows a micrometer head for attachment to machines and tools where fine adjustment is necessary. This head is made adjustable for slight variations, and it has neither a ratchet stop nor lock-nut. The distance from the shoulder

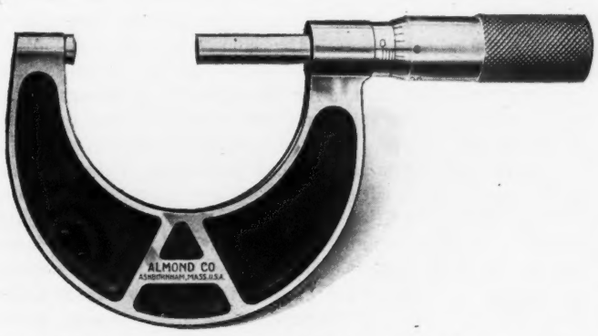


Fig. 2. Almond No. 139 Micrometer for 1 to 2 Inches or 2 to 3 Inches, and No. 142 for 25 to 50 Millimeters or 50 to 75 Millimeters

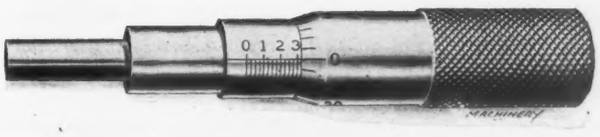
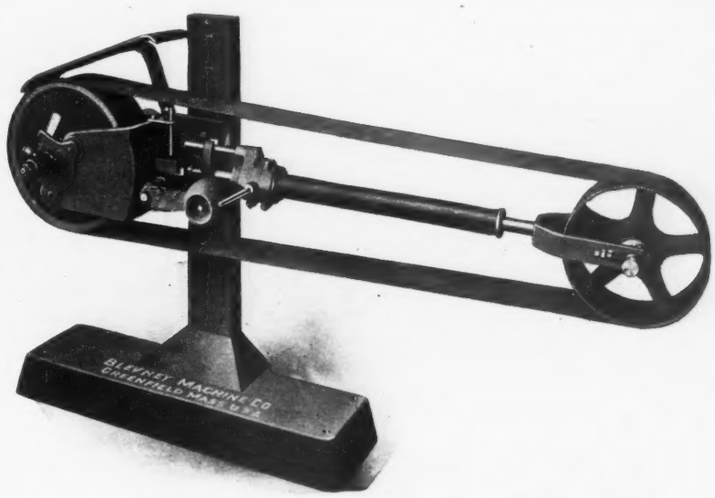


Fig. 3. Almond No. 138 Micrometer Head for 0 to 1 Inch and No. 143 for 0 to 25 Millimeters

to the end is 9/16 inch and the diameter is 27/64 inch. This micrometer head is made in a No. 138 style to read from 0 to 1 inch, heads of this style being made in two types to read to 0.001 and 0.0001 inch. This micrometer head is also made in a No. 143 style to measure work from 0 to 25 millimeters; it is graduated to read to 0.01 millimeter.

BLEVNEY FINISHING MACHINE

In the accompanying illustration is shown one of the recent additions to the line of abrasive belt finishing machines built by J. C. Blevney, 209 Parkhurst St., Newark, N. J. This is known as a Type B-6 machine and takes the place of an ordinary set-up wheel for hand-finishing. It is equipped with a wheel that has a cushion, by means of which roughing operations as well as the finest finishing can be performed by simply changing the abrasive belt. This means that a piece of work roughed with the cushion, which, by the way, is such that no flat or digging-in cuts can be produced, will be followed absolutely with the cutting of finer grit belts. The



Type B-6 Abrasive Belt Finishing Machine built by J. C. Blevney

entire mechanism is mounted on a stand with provision for raising, lowering or setting the belt at an angle.

The cushion wheel is made with the face built up from strips of leather held edgewise by clamps, with spaces 1/16 inch wide between the strips. In operation, these strips of leather tend to bend over slightly so that the edges grip the abrasive belt and serve the double purpose of forming a cushion and increasing the grip on the abrasive belt, which is proportionate to the amount of power required for the polishing operation upon which the machine is engaged. In time there is a tendency for these leather segments to assume a permanent set in the bent-over position, and to correct for this condition, means are provided for removing the wheel quickly from its bearings and reversing it end for end. In this composition it will be apparent that the leather segments tend to bend back in the opposite direction to that in which they have become permanently distorted. A counterweight maintains the desired tension on the abrasive belt.

Attention is called to the fact that it takes only a short time to train an operator to use this machine, which is an important condition at the present time, when skilled labor of any kind is extremely hard to get. It is also stated that the cost of abrasives for the performance of polishing operations is reduced nearly 50 per cent, while the rate of production is increased from 40 to 100 per cent.

RIVETT AUTOMATIC RADIAL GRINDER

In previous types of oscillating radial grinders the mechanism imparts a variable rate of travel to the oscillating head and a fixed rate of cross-feed to the work-head. In the present machine these two principles have been reversed, the mechanism imparting a fixed rate of travel to the oscillating head throughout its stroke and an adjustable rate of cross-feed for the work-head. A fixed rate of travel for the oscillating head allows the grinding wheel to remain in contact with each portion of the complete arc for the same period of time, thus tending to produce greater uniformity in the work. The variable cross-feed mechanism enables the operator to remove the metal rapidly while roughing out the groove in the bearing race and then slow down the feed and take a fine cut while finishing.

The Rivett Lathe & Grinder Co., Brighton, Boston, Mass., has developed a new type of automatic radial grinder, intended for all classes of radial grinding in general, and especially for ball races, both external and internal, radial thrust bearings, spherical shapes of large diameter and spherical sockets. As the work-carrying head can be set to swing through an arc of 200 degrees, complete ball and socket shapes may be ground if required. The machine has a capacity for grinding both inside and outside work up to a diameter of 10 inches, and will chuck work up to a diameter of 12 inches. The grinding diameter of 10 inches may be exceeded on certain classes of work, where the shape of the work permits grinding even larger diameters. The minimum size of work for which the grinder is intended is 3 inches grinding diameter. Smaller work may, of course, be ground, but the builders do not recommend it for much smaller work, as they believe that in such cases a hand-operated machine should be used rather than an automatic machine. The machine is known as the "Rivett No. 208 full automatic radial grinder," and was developed by F. H. Halstead, chief engineer of the Rivett Lathe & Grinder Co., under its new management.

The advantages claimed for the new machine are as follows: (1) The oscillating head of the machine has a fixed rate of travel throughout the oscillating stroke. (2) The cross-feed of the wheel-carrying head is variable, so that the operator may remove a larger quantity of stock at the beginning of the grinding than toward the end; this change in the cross-feed is effected automatically. (3) A great range of feeds may be obtained from a maximum to a minimum, and there is an arrangement for any combination of feeds, coarse and fine, as mentioned under (2). (4) Provision is made for automatic stopping of the machine at the point at which the predetermined amount of stock has been removed from the part being ground. (5) The work-carrying head always stops with the work facing the operator, in position for gaging. (6) The wheel-carrying spindle is removed from the work for gaging by a single motion of a hand-lever. This is the case both for outside and inside grinding. (7) The longitudinal slide of the wheel-carrying head has been eliminated, and the cross-slide is mounted directly on the upper base casting of the machine. This greatly increases the rigidity and minimizes wear. (8) The clutch has been eliminated between the oscillating mechanism and the oscillating member. (9) The machine is heavily constructed throughout, especially the oscillating members. (10) An oscillation of 200 degrees is possible, making it feasible to grind all classes of spherical work without additional attachments.

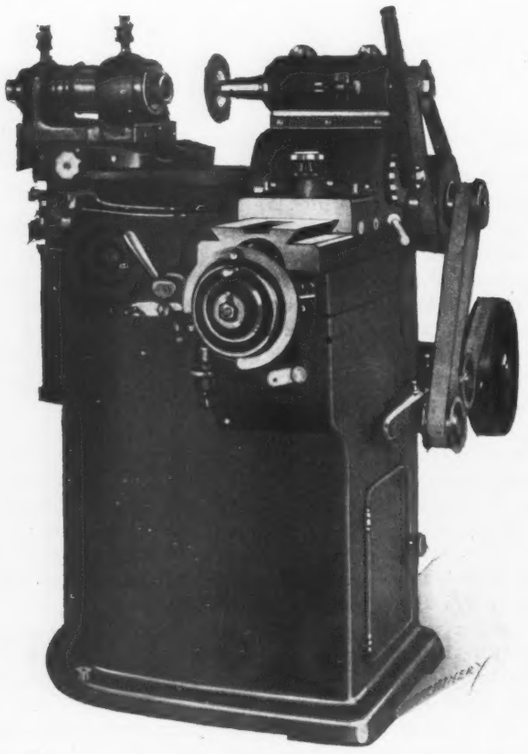


Fig. 1. Front View of Rivett No. 208 Full Automatic Radial Grinder

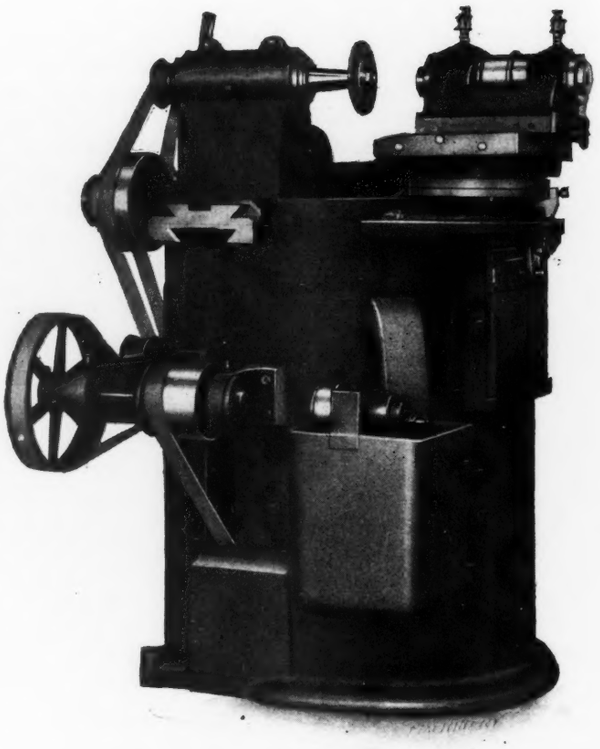


Fig. 2. Rear View of Rivett Grinder, showing Water Attachment

With regard to the construction, attention is called to the following features: All the bearings are ball bearings, except that for the oscillating post, which is solid, and the headstock spindle bearings, which are of the standard Rivett construction. The use of ball bearings has been extended even to the ceiling countershaft, and to all countershaft and pulley bearings on the machine. All parts of the shifting and oscillating mechanisms operate in oil baths. The worm and worm-wheels for the oscillating mechanism are made of machine steel and are casehardened.

The machine consists principally of a wheel-carrying head mounted on a cross-slide and a work-carrying head mounted on an extension from an oscillating post, making it possible to oscillate the work to obtain the spherical form in grinding; means for driving the wheel-spindle; cross-feed for the wheel-carrying cross-slide; means for transmitting and reversing the motion of the oscillating post; and a suitable base or frame for mounting the parts. Power is transmitted from an overhead countershaft to a small pulley at the rear of the machine. On the same shaft with this pulley are mounted two other pulleys, one large and one small. The large pulley transmits power to the wheel-spindle by means of idlers and an intermediate two-step pulley. The small pulley transmits power to a pulley mounted in the base of the machine, from which the power is ultimately transmitted to the oscillating mechanism as follows: By referring to Fig. 3, it will be seen that on the same shaft as that on which the pulley in the base of

the machine is mounted there is also keyed a sprocket, from which a link-belt chain transmits motion to sprocket *A*, keyed to the same shaft as gear *B*. The latter gear, in turn, drives two gears *C*, one on each side. These are mounted on the same shafts as worms *D*, which, one at a time, mesh with a worm-wheel and drive it alternately, first in one direction and then in another. This worm-wheel is fastened to the oscillating post, and it is through this mechanism that the work-head is swung, first in one direction and then in the opposite.

The means by which the worms *D* are shifted to engage alternately with the worm-wheel are shown in Figs. 3 and 4. Referring first to Fig. 3, it will be seen that gears *B* and *C* and worms *D* are all mounted on a bracket *F*, pivoted at *G*, and having a limited oscillating movement actuated by the shifting mechanism shown in Fig. 4. As the work-carrying head, carried by an extension of the oscillating post, moves toward one end of its circular arc stroke, a dog engages with a sliding arc on the under side of the upper base flange. This sliding arc is provided with a forked bracket, which, in turn, engages stud *I*, Fig. 4, on shifting plunger *J*. To the lower side of plunger *J* is fastened a piece *K* having cam surfaces at the ends. These cams, in turn, actuate levers *L* (either the one to the right or the one to the left, according to the direction in which plunger *J* is shifted), and levers *L* press upon

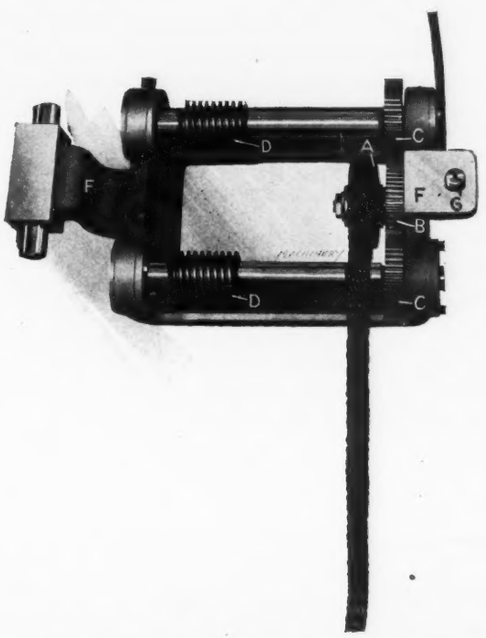


Fig. 3. Details of Oscillating Mechanism for Rivett Grinder

plunger *M*, compressing a spring, as long as part *O*, which is integral with the oscillating bracket *F*, Fig. 3, is prevented from moving by catch *P*. As cam *K* moves forward, however, it raises end *R* of lever *L* until it engages the upper end of the slot in link *S*, thereby raising catch *P* and releasing part *O*, which is then suddenly thrown over by the spring already compressed by the pressure of lever *L* on plunger *M*. This suddenly shifts the frame of bracket *F*, Fig. 3, so that the worm *D* and the worm-wheel on one side are thrown out of engagement, while the worm *D* on the other side is brought into engagement with the worm-wheel.

When it is desired to stop the oscillating movement of the machine, a handle, shown to the left in the front view of the machine (lower handle), is operated, by means of which a plunger is brought into play which acts as a stop for the oscillating frame *F*, Fig. 3, and which stops the frame in a neutral position, so that the worm-wheel does not engage with either of the worms *D*. To start the machine again, the upper of the two handles, shown at the front of the machine to the left of the cross-feed mechanism, is operated. This handle withdraws the stopping plunger, and the oscillations continue. An arm from the oscillating bracket *F* connects with a toggle-joint arrangement from which the movement for the cross-

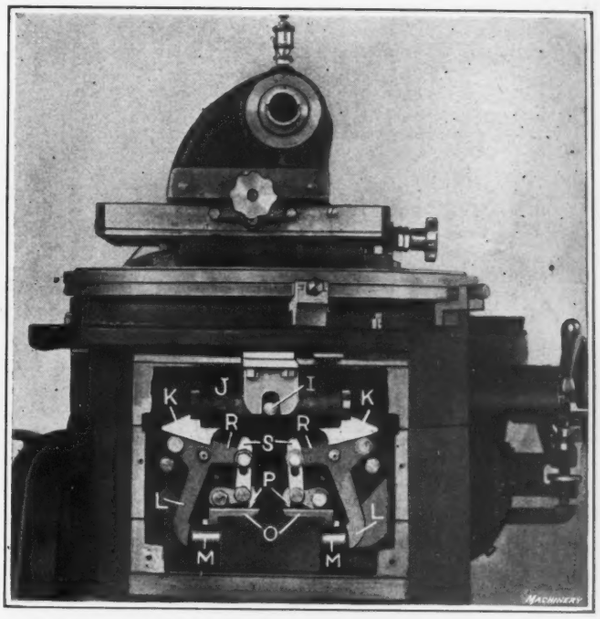


Fig. 4. Details of Mechanism for shifting Oscillating Drive on Rivett Grinder

feed ratchet wheel is obtained. The cross-feed, which is one of the patented features, is provided in the first place with a simple adjusting collar, by means of which the amount of feed movement obtained from the toggle-joint is adjusted from a maximum to a minimum, and, further, with a device by means of which the amount of feed is automatically decreased as the grinding progresses. The first adjustment directly limits, by means of the adjusting collar, the amount of vertical travel of the plunger, to the end of which the pawl for the ratchet wheel is fastened. In this way, any number of teeth or notches on the feed ratchet may be engaged.

The second adjustment, for automatically decreasing the feed, is accomplished by operating the vertical plunger also, but through the cross-feed mechanism itself, which can be set for any required decrease. When the required size has been reached, as predetermined by previous gaging and setting, the cross-feed mechanism throws out the feed by engaging the stopping handle at the left of the cross-feed dial shown in the front view. To the right of the machine is a hand-lever for moving the wheel-slide back and forth by hand. The spindle for the wheel is adjusted to the correct position for a given radius by a small adjusting screw on the side of the wheel-carrying head. The work-carrying head is mounted on a cross-slide, which, in turn, is mounted on the extension of the oscillating post. The work-carrying head is adjustable longitudinally, while the cross-slide provides transverse adjustment.

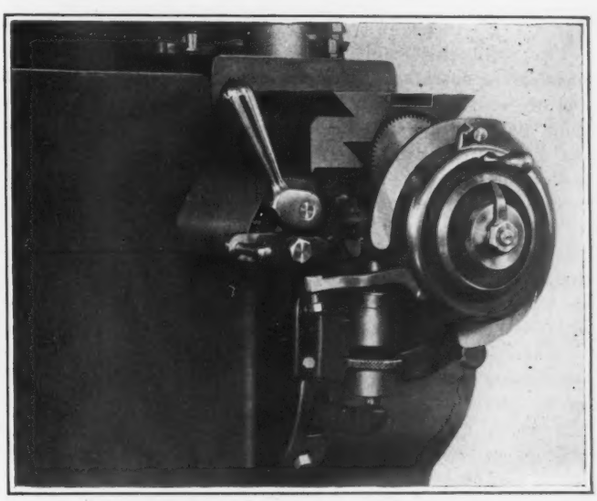


Fig. 5. Cross-feed Mechanism of Rivett No. 208 Automatic Oscillating Grinder

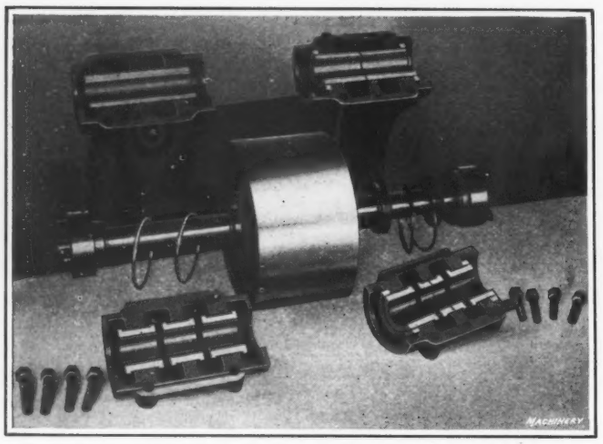


Fig. 1. Spindle and Ring-oiling Bearings of Besly Disk Grinder

BESLY SPINDLE CONSTRUCTION

Charles H. Besly & Co., 120-B N. Clinton St., Chicago, Ill., are now building disk grinders equipped with dustproof, automatic, ring-oiling radial and thrust bearings for the spindle. The bearings are equipped with inserted phosphor-bronze bushings, which are removable. It is claimed that these Besly ring-oiling bearings are so arranged that the spindle literally floats in oil, which results in considerably reducing the power required to drive the machine. Tests conducted to determine the transmission efficiency of these ring-oiling bearings are said to have shown that it is within 2 per cent of the efficiency of a ball bearing. The bearings are dustproof and automatically lubricated, so that a minimum amount of attention is required. Old oil should be drawn off and fresh oil substituted once in three to twelve months, depending upon the amount of service obtained from the machine. The oil-wells are of large capacity; for instance, on the No. 17 Besly grinder with a spindle 2½ inches in diameter, the oil-wells are 7 inches deep.

Two solid steel oil-rings are provided for each bearing. These rings operate through channels in the bearing bushings and are so designed that it is impossible for the rings to become displaced and fail to function properly. A perfect flood of oil is continually transmitted to the radial and thrust bearings while the grinder is running, and the oil channels in the faces of the thrust bearings are of a special design, which sets up a pumping action that forces oil between the thrust collars. The bearing bushings are split and of the inserted type, so that they are easily renewed. These bushings are made of a special grade of phosphor-bronze, and the bearing surfaces are of large size so that there is practically no wear. End thrust is taken on hardened and ground tool steel collars against the flanged ends of the right-hand bushing. End play is taken up by means of adjusting collars threaded onto the spindle and located under the rim of the spindle pulley. Besly grinders may be safely operated with all end play taken up in the spindle. The bronze bearing bushing which receives the end thrust is provided with clearance to compensate for any expansion that may take place in the bushing. Therefore, it is impossible for this bearing to bind between the thrust collars and cause them to seize. This is an important feature, as any looseness or end play in the spindle will naturally affect the accuracy of the work being ground.

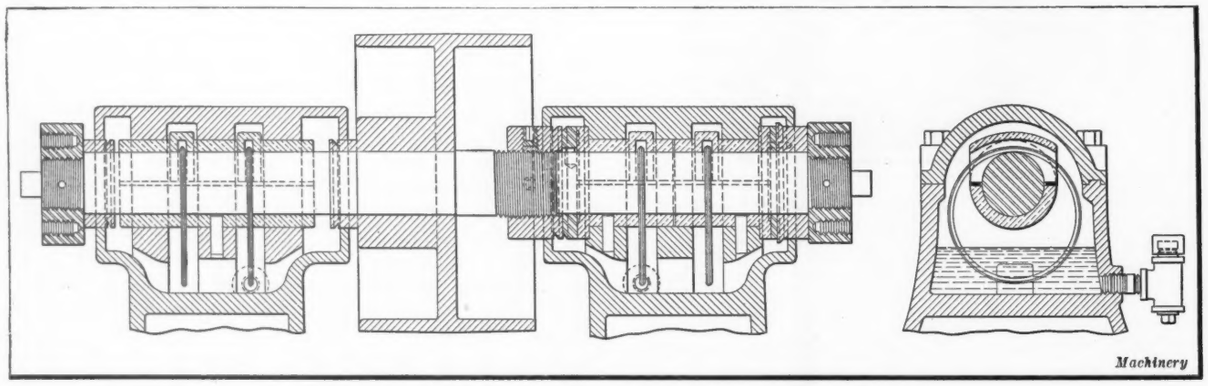
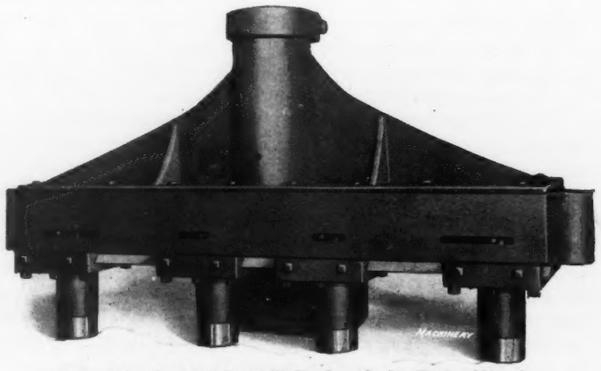


Fig. 2. Section through Spindle and Ring-oiling Bearings of Besly Disk Grinder

HOEFER HEAVY-DUTY DRILL HEAD

One of the recent products of the Hoefer Mfg. Co., Freeport, Ill., is a heavy-duty, four-spindle auxiliary drill head, which is capable of driving twist drills up to 1 inch in diameter. The head is clamped to the machine by a nose reaching up to the spindle sleeve; and the heavy case is amply supported by webs. A taper shank provided with a toothed driver transmits power to the head, after which the transmission is through hardened helical gears on a horizontal shaft which extends the full length of the head. These gears are made of sufficient length to afford the amount of adjustment that is called for. By having bearings of ample size throughout the head, with all bearings bronze bushed, there is no opportunity for the helical gears on the long driving shaft to spring away from the gears on the spindles. Half the helical gears are made of opposite lead from the other half in order to balance the end thrust as far as possible; but as a further precaution against trouble from this source, large ball-thrust bearings are provided at each end.

The spindles of the drill head are made of hardened steel and driven by the helical gears to which reference has already been made. These spindles run in bronze-bushed bearings. A ball thrust bearing is contained in a cupped spindle nut at the lower end of each spindle in order to eliminate as much friction as possible; and this bearing is protected from dirt and dust. Each spindle is carried in an adjustable spindle bearing, which slides in a scraped bearing and is locked by set-screws. As the bearing is faced down on the under side of the head, the thrust is taken directly by the bearing without any tendency to cock the bearing out of alignment. Adequate provision has been made for the lubrication of this drill head. The lower bearing of each spindle is lubricated through oilers appearing through slots on the sides; and the helical gears run in a small pocket filled with oil, which insures perfect lubrication at all times.



Heavy-duty, Four-spindle Drill Head made by Hoefer Mfg. Co.

NEW MACHINERY AND TOOLS NOTES

Oil-cups: Gits Bros. Mfg. Co., 553-557 W. Monroe St., Chicago, Ill. A line of oil-cups furnished with hinged tops that can be opened with the tip of the oil-can spout. In making these cups all parts are brazed together, and it is claimed that they are as strong as cast cups.

Grinding Machine: S. B. Patch & Sons Co., Streator, Ill. A line of double-spindle grinding machines which are equipped with self-oiling babbitted bearings. These machines are built in three sizes for wheels 10, 14 and 18 inches in diameter. The general design of the three sizes of machines is the same.

Machine Vise: Moback Tool & Machine Mfg. Co., 330 Atlantic Ave., Boston, Mass. A line of vises for use on milling machines, drill presses, grinding machines, shapers, planers, etc. These vises are built with either swivel or plain bases, the swivel base being an additional equipment for the plain vise. The swivel base is graduated in degrees.

Sandblasting Machine: Mott Sand Blast Mfg. Co., Inc., Brooklyn, N. Y. A machine equipped with a separate sand-blast apparatus for each barrel. Abrasive material is elevated mechanically by a belt and bucket elevator, and passed through a mechanically operated screen. Machines of this type are made in various sizes to meet the requirements of different shops.

Stock Bin: Hobart Bros. Co., Troy, N. Y. A stock bin for storing nuts, bolts, screws and other small parts in the machine shop or tool-room. It contains 120 compartments measuring 6 by 8 by 10 inches. The front partition and the ends of the bin are of oak, while the back is made of sheet steel. Each compartment is furnished with a metal card-holder for indexing.

Forging Hammer: Chambersburg Engineering Co., Chambersburg, Pa. A double-acting steam forging hammer of unusually large size which has been built for the Washington Steel & Ordnance Co., Washington, D. C. This is said to be the largest hammer of its type ever built in the United States. It is known as a 40-ton, double-frame, double-acting steam forging hammer.

Voltmeters and Ammeters: General Electric Co., Schenectady, N. Y. A series of miniature voltmeters and ammeters for use on direct-current circuits. These instruments may be used on circuits from 10 to 150 volts and from 10 to 150 amperes. The light weight moving elements are mounted in jeweled bearings, and to provide complete insulation all parts of the measuring elements are mounted on a bakelite base.

Gang Drilling Machine: Barnes Drill Co., 814 Chestnut St., Rockford, Ill. A three-spindle, 22-inch, all-geared gang drilling machine, which is provided with eight changes of speed and ten changes of feed for each spindle. All changes are under constant control of the operator from the front of the machine and are independently operated. Any or all of the spindles may be equipped with an automatic reversing mechanism.

Paint Spraying Equipment: Spray Engineering Co., 93 Federal St., Boston, Mass. An outfit known as the P-1 painting apparatus, which may be used for applying all kinds of liquid coatings and is portable, thus being adapted for either shop or field use. This outfit is operated by compressed air at a pressure of from 35 to 75 pounds per square inch, the amount of pressure depending upon the material to be applied to the work.

Dump Car: Easton Car & Construction Co., Easton, Pa. A dump car for use on industrial railroads. On this car two sets of wheels are employed and the car is furnished with crane lifting rings attached to the top of the body at each end. In this way the body of the car can be lifted off the carrying truck, which runs on a standard gage track, and be set down on another track of narrow gage on which the second set of wheels runs.

Drilling Machine for Recoil Cylinders: Charles Stecher Co., 1574 Crossing St., Chicago, Ill. A line of machines for drilling holes in recoil cylinders, these machines being a further development of the company's tools for drilling holes in lathe spindles. The drill is mounted in a vertical position and fed upward into the work, which provides for easily clearing chips from the hole. This machine is adapted for boring holes up to 3¾ inches in diameter by 63 inches long.

Variable-speed Pulley: Charles M. Terry, Inc., 25 Broad St., New York City. This pulley was developed by W. B. Dunbar, Sydney, Australia, and Mr. Terry has the American agency. With this mechanism it is possible to vary the velocity ratios between the driving and driven shafts without interrupting the transmission of power. Various arrangements can be provided for operating the mechanism, such as a long lever and notched quadrant, a handwheel or a short lever.

Band Re-saw: Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich. A machine known as a No. 15-R 38-inch combination re-saw and band-saw. The change from re-sawing to ordinary band-sawing is instantly effected by swinging the arm carrying the two corrugated rolls out of the way and changing the saws. The table tilts 45 degrees in one direction and 5 degrees in the other direction, and it is double ribbed and supported on rockers for angle adjustments.

Hardness Tester: Palo Co., 90 Maiden Lane, New York City. An instrument for measuring hardness of metals which was devised by Leonard Waldo, a New York consulting engineer. This instrument may be easily transported from place to place, and its indications are uniform over definite periods of time. The test is made by allowing a plummet weighing 0.10 pound and provided with a hardened steel point to drop one foot upon the material whose hardness is to be tested.

Heavy-duty Engine Lathe: Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich. This company has recently made a number of changes in the 16-inch heavy-duty engine lathe of its manufacture. The headstock is made of the bowl type to afford better protection for the belt, and new gear covers have been provided. The tailstock has been made longer and heavier; and a lubricant reservoir has been placed on the under side of the oil-pan. Oil-wipers are furnished on the carriage.

Hardness Testing Machine: Scientific Materials Co., Pittsburg, Pa. This machine is known as the "Scimatco" Brinell hardness testing machine. It is provided with a hydraulic press having a heavy base in which the hand-power gear for operating a screw to produce pressure is located. The upper part carries the hydraulic piston, upon the ram of which is mounted the standard hardened steel ball to be forced into the material under test.

Extensometer: Riehle Bros. Testing Machine Co., Philadelphia, Pa. An extensometer for measuring the elastic limit of steel. This apparatus has a feature not heretofore provided, namely, means for attaching it to the opposite sides of the test-bar to indicate the actual mean stretch between the two points. There are no electrical contacts, no adjustments of a micrometer screw, and no readings of a micrometer. Readings can be taken from a stress-strain curve at equal increments of load while the machine is running.

Universal Miller: Ford-Smith Machine Co., Ltd., Hamilton, Ontario, Canada. A No. 2 universal miller on which the working surface of the table is 41½ by 10 inches and is provided with three ⅝-inch T-slots. The longitudinal feed is 25 inches; cross-feed, 8 inches; and vertical feed, 18 inches. The available range of spindle speeds is from 12 to 360 revolutions per minute, and the nine available feed changes range from 0.006 to 0.055 inch per spindle revolution. The floor space occupied by the machine is 81 by 98 inches, and the machine weighs 3150 pounds.

Plate Punch Table: Norbom Engineering Co., Denckla Bldg., Philadelphia, Pa. An equipment known as the "Lysholm" plate punch roller table, which is especially adapted for the rapid handling of plates on the punching machines used in shipyards. In using this plate punch roller table, the plate is laid on the table, and from his seat the operator moves the table backward and forward with the aid of an operating lever at his right hand. A lever at the left hand can be operated to move the plate sideways. In this way the desired location is obtained for punching.

Pipe Threading Attachment: Curtis & Curtis Co., 8 Garden St., Bridgeport, Conn. When the attempt is made to thread wrought iron or steel pipe on an ordinary lathe, trouble is likely to be experienced. To meet the requirements of this work where the amount of pipe threading to be done does not warrant purchasing a regular threading machine, a lathe attachment has been developed. This attachment is said to convert a lathe into the equivalent of a power pipe threading machine, and pipe of any length may be rapidly and accurately threaded on a machine provided with this attachment.

Universal Drill Jig: Berggren & Pearson Machine Co., Inc., 221-227 Canal St., New York City. A universal drill jig designed to meet the requirements for a tool that can be rapidly and easily adjusted for handling various sizes and types of work. The device consists of a baseplate and two uprights that are machined with a number of T-slots, by means of which the bushing bars and stops for holding the parts to be machined are fastened in place in the jig. The drill bushings are hardened and ground to size and are furnished in sizes from ⅛ to 1½ inch in diameter, special sizes being made to order. Each jig is supplied with four bushing bars and eight bushings of selected sizes.

Computing and Shell Scales: Computing Scale Co., Dayton, Ohio. Two scales, one of which is a computing scale of the beam type with a capacity for handling loads up to 600 pounds. The tare beam has a capacity of 100 pounds and is sensitive to ½ ounce, while the counting beam is graduated for use when one, five or ten units are placed in the pan. A third beam may also be provided which reads directly in pounds. The other scale referred to is a munition and shell scale; a master or standard weight is placed on one scale pan and a shell is placed on the other pan, and the amount it is over or under weight may be read directly on the scale. The scale is graduated to read in steps of 1/16 ounce for weights up to 4 ounces.

HARRIS LEAD AND ANGLE TESTING DEVICE FOR THREAD GAGES

The thread gage is one of the most difficult gages to make accurately and also to measure accurately. Many mechanics who have attempted to make thread gages have given the proposition up as a bad job for several reasons. One was the difficulty of obtaining machinery accurate enough to do the work, and another was the difficulty of obtaining equipment for measuring thread gages; furthermore, there is a lack of men skilled in the manufacture of thread gages, which is partly due to the fact that many thread gage makers take the first chance they get to find an easier way of making a living. The making of thread gages has been confined to a comparatively few manufacturers; these have made a special study of the requirements and have been fairly successful on account of their familiarity with this branch of work and the lack of familiarity of many of their customers, who simply took what was given to them, and believed that the gages must be right because of the standing of the firm that supplied them. During the last two years, however, there has been considerable education among users of thread gages. Engineering societies, large munitions makers and manufacturing concerns now realize that some of their most difficult problems are connected with the production of screws, taps and tapped holes that are up to the required standards of accuracy. In the manufacture of taps, hobs for hobbing dies, male thread gages and hobs for female thread gages, the question of correct lead and correct angle of the thread has been found to be more important even than the correct diameter measurement, and while a number of gages of different types have been developed for checking the angle or the lead, hardly any of them, if any, are sufficiently accurate and reliable for the accurate checking of angle and lead.

The problem has been to design a screw thread testing device for testing the angle and the lead which is rigid and substantial, thoroughly accurate, and upon which a small degree of error may be easily ascertained. In testing the truth of a flat surface, a knife-edge straightedge is used, as the smallest amount of error (even less than 0.0001 inch) will readily show light between the surface tested and the knife-edge. This principle seems to be the most simple and reliable one to employ in testing lead and angularity. Two curving surfaces coming together on a line of contact will show light through an inequality as readily as a knife-edge gage on a flat surface, and will even show more light. The thread lead and angle measuring machine to be described is based on this principle; that is, of seeing light between two curved surfaces. If they do not coincide, it is claimed that 0.0001 inch can be detected by a person with ordinary eyesight, and with the aid of a magnifying glass, 0.00005 inch can easily be seen.

Arrangement of Lead and Angle Testing Machine

Referring to Fig. 1, which is a general view of the lead and angle measuring machine, the solid and substantial construction will be noted. The machine has a heavy cast bed *A* and a stationary head *B*, which carries a fixed center *O* and is permanently fixed to casting *A*. The sliding tailstock *C* can be clamped positively to the bed *A*, by means of the two clamping screws *Q*, and carries a spring center *P*, which can be withdrawn by the knob *E* or clamped in position by the screw *F*. The gage *H* to be tested is put between centers by placing one center upon center *O*, bringing up the tailstock *C*, clamping it by screws *Q*, and allowing the center *P* to enter the opposite center of the gage, as it is forced outward by a spring inside of *C*. Center *P* is clamped in position by handle *F*. So far the means described are simply to hold the gage true between the centers and in correct alignment with the measuring devices, which are carried on the slide *D*. This slide is carefully fitted to the bed *A* and is clamped into the position required by the thumb-screw *G*. It consists primarily of a compound slide which is carefully and accurately made, so as to be in correct alignment with the axial line through the centers *O* and *P* of the measuring machine, all planes and surfaces being either accurately perpendicular or accurately parallel to this axis.

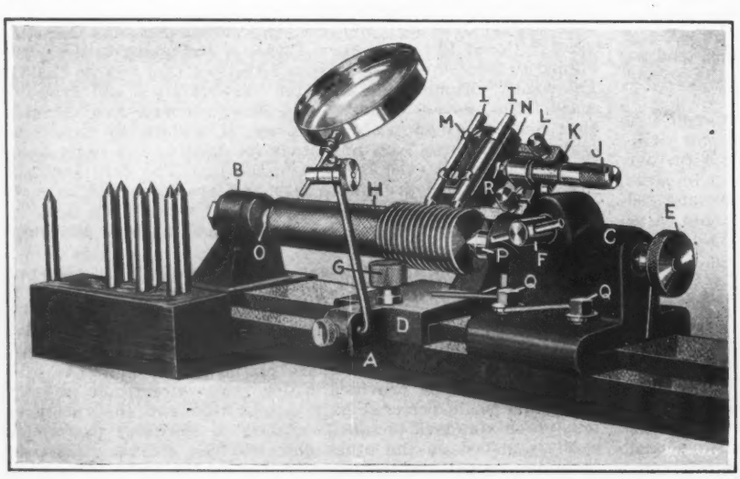


Fig. 1. Harris Lead and Angle Testing Machine for Screw Threads

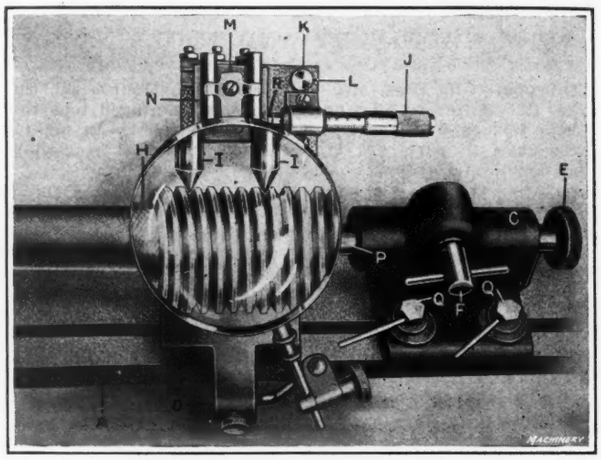


Fig. 2. Detail View, showing Testing Points Magnified

The lower member of the compound slide *K* is adjustable in toward and out from the line of centers through *O* and *P*, and may be clamped by screws *L* in whatever position is suitable for the diameter of the thread gage to be measured. This slide carries a micrometer head *J*, which operates against a hardened stud *R* in the upper member *N* of the compound slide. The upper part *N* is free to move laterally parallel with the axial line through the centers *O* and *P*. This movement can be measured by the micrometer head *J* or by the use of distance blocks or Swedish gages placed between the point of the micrometer (which is clamped in position) and the point *R* on the upper member *N*. The latter carries two angle test-pieces, which are held by the spring clip *M*. This spring clip permits adjustment by finger pressure toward or away from the gage or thread to be tested. The center-to-center distance between the angle test-pieces *I* is just one inch, which is a basis for checking error of lead in gages that are to English measurement and are over one inch long. For metric screw threads or threads less than one inch long, either the micrometer or proper distance gages, such as Swedish gage blocks, are used between the point of the micrometer and the stud *R* on the slide. Fig. 2, which represents a view through a magnifying glass, shows the points of these angle test-pieces on an enlarged scale, and it can be seen how they fit the angle of the threads on the gage, which is shown in position.

Testing Lead of Screw Thread

In testing the lead, the first operation is to turn the thread gage on the centers of the machine until the thread will allow test-

ing point *a* (see diagram *A*, Fig. 3) to engage it as shown at *B*, thus shutting out light on both sides of the conical point. This is done merely by rotating the gage by hand in between the centers of the machine, and gives it a very fine adjustment. After point *a* has been pressed down lightly in the direction of the arrow, point *b* is brought down in the same direction until it touches the thread. If the lead on the thread gage is short, the effect will be as shown at *C*, which has been exaggerated to illustrate the point clearly. If the lead on the thread gage is long, the effect will be as shown at *D*.

The problem now is to determine the amount that the lead on the thread gage is long or short. With the micrometer adjusted against point *R* (see Figs. 1 and 2) and set at zero, point *a* is drawn back from the threads as shown at *E*, Fig. 3, which permits moving point *b* in either direction. If the lead on the gage is long, as at *D*, point *b* is moved in the direction of the arrow as at *E*, by means of the micrometer screw, and when it is opposite the thread it is moved down in the direction of the arrow as at *F*. The amount that it has moved over (as indicated by *x*) is the extent that the lead of the gage is long in one inch.

If the lead is found to be short, the order of operations is reversed. The amount *x* could be measured either by the micrometer direct or with a Swedish block placed between the micrometer point and the point *R*. If the thread on the thread gage is not over one inch long, only one of the measuring points is used, and in this case either point *a* or *b* is engaged with the screw thread wherever the lead is to be checked. The distance *x* as measured either by the micrometer or Swedish block is compared with the nominal or correct distance, and the difference is the error in lead for that number of threads.

Testing Angle of Thread

The methods of testing the angle of the thread with the angle test gages are indicated by Fig. 4. These views simply show the ends of the angle test gages and the contour of the thread in the gage where it is being tested. Sketch *A* shows a standard test angle gage fitted into a thread that has too large an angle. After testing it with the standard plug, a plug with a greater angle is tried, as shown by the dotted line, and in this way the amount of angular error can be ascertained. Sketch *B* shows a gage having a thread angle that is too small. A thread with unequal angles is shown at *C*, and one having concave sides at *D*. These errors show up prominently by the amount of light that passes between the angle test gage and the thread. Threads are often rounded over near the top, as at *E*, as the result of excessive lapping with an old-style lead lap.

Sketch *F* shows how a thread having unequal angles as at *C* can be tested to ascertain the amount of angular error, by placing different angle test-pieces against each side of the thread walls. The angle test gage shown by the full line serves to test one side of the thread wall, while the angle

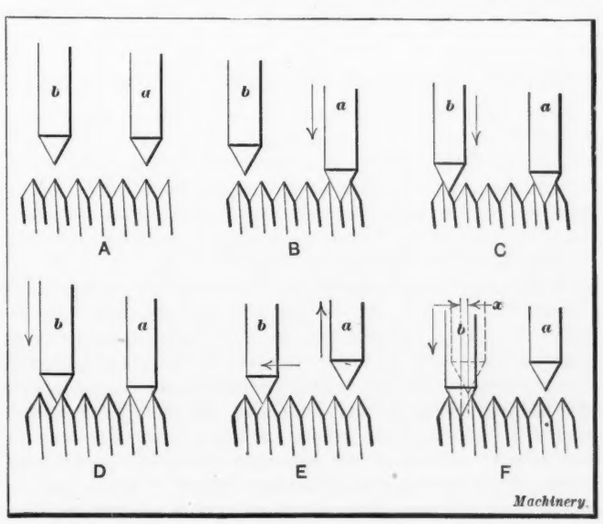


Fig. 3. Diagrams illustrating Methods of adjusting Testing Points and how Lead Errors are detected and measured

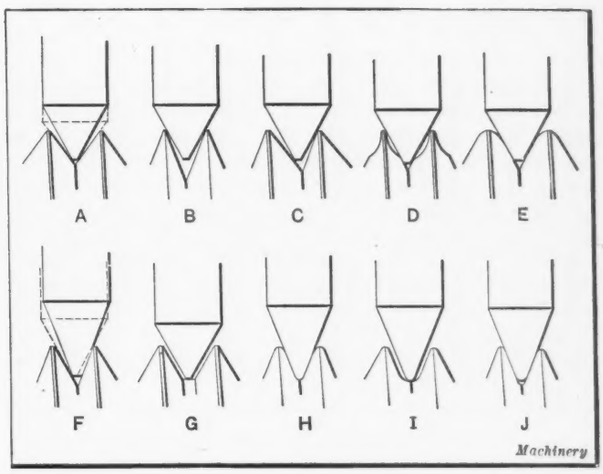


Fig. 4. Various Screw Thread Defects

test gage shown by the dotted line tests the angle on the other side. If the standard angle were 60 degrees and the test-bar shown in full lines were 58½ degrees, whereas the test gage as shown in dotted lines were 61½ degrees, this would show that the thread was "tipped" or leaned over ¾ degree, while the included angle of the thread might be or might not be standard. Diagram *G* shows how the angle test gage discloses that the bottom of the thread groove is too wide, the root diameter being too large.

A Whitworth form of thread is illustrated at *H*, which is correct on the angle and at the bottom. Sketch *I* shows a Whitworth thread that has too large a radius at the bottom of the thread, and *J* shows a Whitworth thread that is correct as to angle, but is cut too deep and has too small a radius at the bottom of the thread groove. Fig. 4 is merely intended to show, in a somewhat exaggerated degree, a few of the diversified defects that this angle and lead testing machine will detect. This apparatus was developed by the H. E. Harris Engineering Co., Bridgeport, Conn. It is used by this company and by the Bureau of Standards.

* * *

AMERICAN GEAR MANUFACTURERS' ASSOCIATION CONVENTION

The American Gear Manufacturers' Association held its semi-annual session in Chicago, September 13, 14 and 15, at the Edgewater Beach Hotel. The association numbers among its members practically all the prominent gear manufacturers in the country. The Chicago session was the largest of any yet convened. The last meeting was held in Pittsburg in May. Special importance was attached to the present meeting because of the members' desire to effect as much standardization in gear products as possible, in keeping with the government's desires for all industry, now that the war is making special demands upon all manufacturers and users of materials.

F. W. Sinram, of Van Dorn & Dutton Co., Cleveland, president of the organization, opened the sessions Friday morning. A paper, "Advertising Don'ts," was then read by J. C. McQuiston, advertising manager of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. W. H. Phillips, of R. D. Nuttall Co., Pittsburg, followed with a talk on the subject "Heat-treating and Hardening of Gears." In the afternoon the convention men were the guests of the Chicago members. An automobile trip of about seventy-five miles through Chicago's huge park system was a feature much appreciated. In the evening a dinner, music, monologues, lantern-slide caricatures and the like provided entertainment for the visitors. All received a first-rate impression of Chicago and enjoyed the day. At the Saturday session, a paper by B. S. Waterman, of the Brown & Sharpe Mfg. Co., "Inspection of Gearing," was read; also one by H. E. Eberhardt, of the Newark Gear Cutting Machine Co., "Spur Gearing by the Rotary or Disk Cutting Process"; and another by F. Schneider, of Van Dorn & Dutton Co., Cleveland, "Spur Gears by the Shaper Method. Lively discussion of the papers brought additional valuable information.

LENGTH OF A WORM OR HOB

BY LUTHER D. BURLINGAME [1]

It is surprising that, after so many years of mechanical development, where worms and worm-wheels have entered largely into the mechanisms used, the question as to the correct length to make the worm should still be one of uncertainty, the rules so far proposed by recognized authorities on the subject giving wide variations. A reason for this uncertainty lies in the fact that there are so many varying conditions affecting the length of contact between the worm and wheel on which the length of the worm depends. Some of these conditions are: diameter of worm and diameter and width of face of worm-wheel, extent of contact on each side of mid-plane, and pitch angle of thread with axis (the extent of contact on the approaching side being increased with increase of helix angle—which is particularly noticeable when a wide-faced worm-wheel is used.) There is also the question of wear in its effect on the length of contact to be considered. Such an authority as George B. Grant, in his "Teeth of Gearing," recommends very short lengths for the worm, claiming that it need not be more than three times the circular pitch, for there are seldom more than two teeth in contact at once. He qualifies this, however, with a statement that: "If the worm is made long it can be shifted when it becomes worn so as to bring fresh teeth into the working position." A rule given by Oscar J. Beale in his "Treatise on Gearing" determines the length of engagement between the threads of a worm and the teeth of its engaging wheel by the intersection of the tops of the threads of the worm with the line of pressure, although he, too, favors, in practice, much longer worms than would result from using this rule.

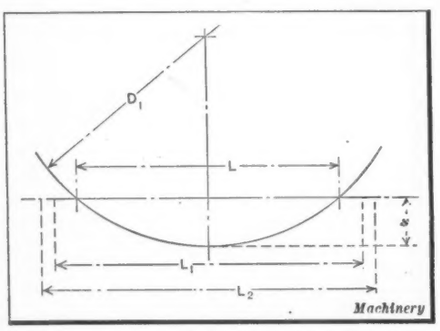


Diagram showing Method of deriving Formula for Length of Worm or Hob

In an analytical paper presented before the British Institution of Mechanical Engineers in 1906, Robert A. Bruce goes into the nature and limitations of tooth contact between worms and worm-wheels, and shows by graphic methods that such contact extends much farther beyond the center line of the worm-wheel in each direction than would be allowed for by following the rules already referred to, as contact extends farther each side of the mid-plane than on it. Mr. Bruce also shows that the path of contact is quite different on the approaching and receding sides, both in nature and extent, his illustration showing that the length of contact may be twice as great as that occurring on the mid-plane only. This length is further increased by wear. This accords with what is found by experience in examples showing the contact produced by actual use.

Investigations made by Ralph E. Flanders and published in MACHINERY for August, 1907, include a rule for the length of worm based on the intersection of a line representing the throat diameter of the worm-wheel with the top of the worm thread. This would insure the worm being sufficiently long, as there could be no additional contact if it were made longer; but such a rule would under some conditions make the worm longer than necessary. In an article on the lengths of worms and hobs, published in MACHINERY for November, 1913, E. Winslow Baxter says that a worm should not be shorter than the length of chord formed by the intersection of the pitch line of the worm-wheel with the top of the threads of the worm; but in the formula and table which he gives, he makes the length greater than this; in fact practically the same as that obtained by the Flanders formula.

[1] Industrial Superintendent, Brown & Sharpe Mfg. Co., Providence, R. I.

While for worm-wheels with a comparatively small number of teeth, the Flanders and Baxter formulas give lengths which accord closely with good practice, for wheels with large numbers of teeth the lengths produced by these formulas would, as already pointed out, seem unduly great. Making the minimum length dependent on the intersection of the pitch circle of the worm-wheel with the top of the thread of the worm, and adding a constant depending on the coarseness of the teeth, gives a formula from which lengths can be obtained for both the worm and hob, which will bring the length of the worm within practical limits for all ordinary conditions, providing also for wear.

The formula suggested, based on the foregoing, is as follows: Let L equal the length of chord, L_1 equal the required length of worm, L_2 equal the length of hob, D_1 equal the pitch diameter of worm-wheel, and s equal the addendum. Then:

$$L = 2\sqrt{s(D_1 - s)}$$

$$L_1 = L + 5s$$

$$L_2 = L + 5.5s$$

D_1 = pitch diameter

It will be sufficiently accurate to carry decimal figures to two places only, or to use a slide-rule. The length of worm or hob should then be made to the nearest even fraction. The length of the worm can be obtained graphically by laying out the pitch diameter D_1 of the largest worm-wheel to engage the worm, and finding its intersection with a line representing the outside diameter of the worm engaging the wheel, as shown at L. To this chord L add $5s$ to obtain the length L_1 of the worm, or if the formula is to be used for determining the length L_2 of the hob, which should be slightly longer than the worm, add $5.5s$ to obtain the length of the hob. If endwise movement of the worm is required for adjustment or traverse, the amount of such movement should also be added, to obtain L_1, but need not be added in this case to the length of the hob. A short worm can be used with a large wheel by having the hob a little longer than the worm, but such use will be at the sacrifice of wearing qualities.

If it is desired to find the length of a worm and of a hob for a worm-wheel having fifty-six teeth of 3/16 inch circular pitch:

$$D_1 = \frac{56}{3.1416} \times \frac{3}{16} = 3.34 \text{ inches} = \text{pitch diameter}$$

$s = 0.0597$ inch = addendum

It will be sufficiently close to call $s = 0.06$ inch. Then:

$$L = 2\sqrt{0.06(3.34 - 0.06)}$$

$$3.34 - 0.06 = 3.28$$

$$3.28 \times 0.06 = 0.1968$$

$$\sqrt{0.1968} = 0.443$$

$2 \times 0.443 = 0.886$ inch $= L =$ length of chord

$0.886 + 5s = L_1$

$0.886 + 0.30 = 1.186$, or about 1 3/16 inch = length of worm L_1

$0.886 + 5.5s = L_2$

$0.886 + 0.33 = 1.216$, or about 1 7/32 inch = length of hob L_2

* * *

MAKING JIGS FROM SQUARE CAST-IRON BARS

In the early days of war contracts, a munitions plant found that it could not receive the castings for its jigs and fixtures until two or three months after the order for them was given, or until long after its competitors would have started to fill their orders. So the manager decided to make these tools himself. He accordingly found the section of a square cast-iron bar that would be necessary to make the largest jig or fixture he would need, and ordered from the foundry enough bars of this size to make all the jigs and fixtures from. He received these bars the next day, for the foundry usually keeps them on hand, and at once cut them to the proper lengths. These pieces he worked to the desired shapes on the planer and milling machines and completed his tools by inserting hardened steel bushings where necessary. By this plan he was able to commence the manufacture of his goods some weeks before any of his competitors, many of whom had received their contracts quite a while before this plant; in addition, he saved the time and expense of making the patterns and castings for the parts.

TIME-RING DISK-SEAT RECESSING MACHINE

BY DONALD A. BAKER [1]

The machine shown in the accompanying illustration is for milling the disk seat *a* in the Type 80 time-fuse ring shown in detail at *A*. The unique features of the machine are the oscillating cutter-spindle, and the method of locating and holding the work in the jig. The frame of the machine is of cast iron. The spindle *B* is hollow and contains a small spring collet for holding the cutters and a draw-rod for tightening the spring collets. It runs in ball bearings, both front and rear. The housing in which it is contained is pivoted at *C* in a bronze bushing, a hardened pin being driven into a boss on the under side of the spindle housing, as shown. The wings *D* of the housing are machined and scraped; they have a bearing on top of the machine frame and are held down by the two straps *E*, which eliminate any tendency of the spindle to lift, but are so made as to allow play sidewise. This movement is what determines the amount of elongation of the disk seat, and it is controlled by an eccentric cam *F*, acting through the link *G* that connects with the arm *H*.

In order to control and adjust the movement, the eccentric cam is made a good fit in an eccentric hole in the shaft *I* that drives it. This shaft has one end enlarged, and a set-screw in it holds the eccentric cam when properly adjusted. The throw of the cam can be regulated by turning it to different positions in the eccentric hole in its driving shaft, because of the difference in eccentricity of the shaft and cam. At the opposite end of the eccentric driving shaft is mounted a grooved pulley for taking a round belt as shown. Shaft *I* is mounted in a bearing that is bolted to a pad on the side of the machine frame and has vertical adjustment. This movement is sufficient to adjust the spindle sidewise, after the proper throw has been obtained by adjusting the eccentric cam.

[1]Address: Layman Pressed Rod Co., 1790 Broadway, New York City.

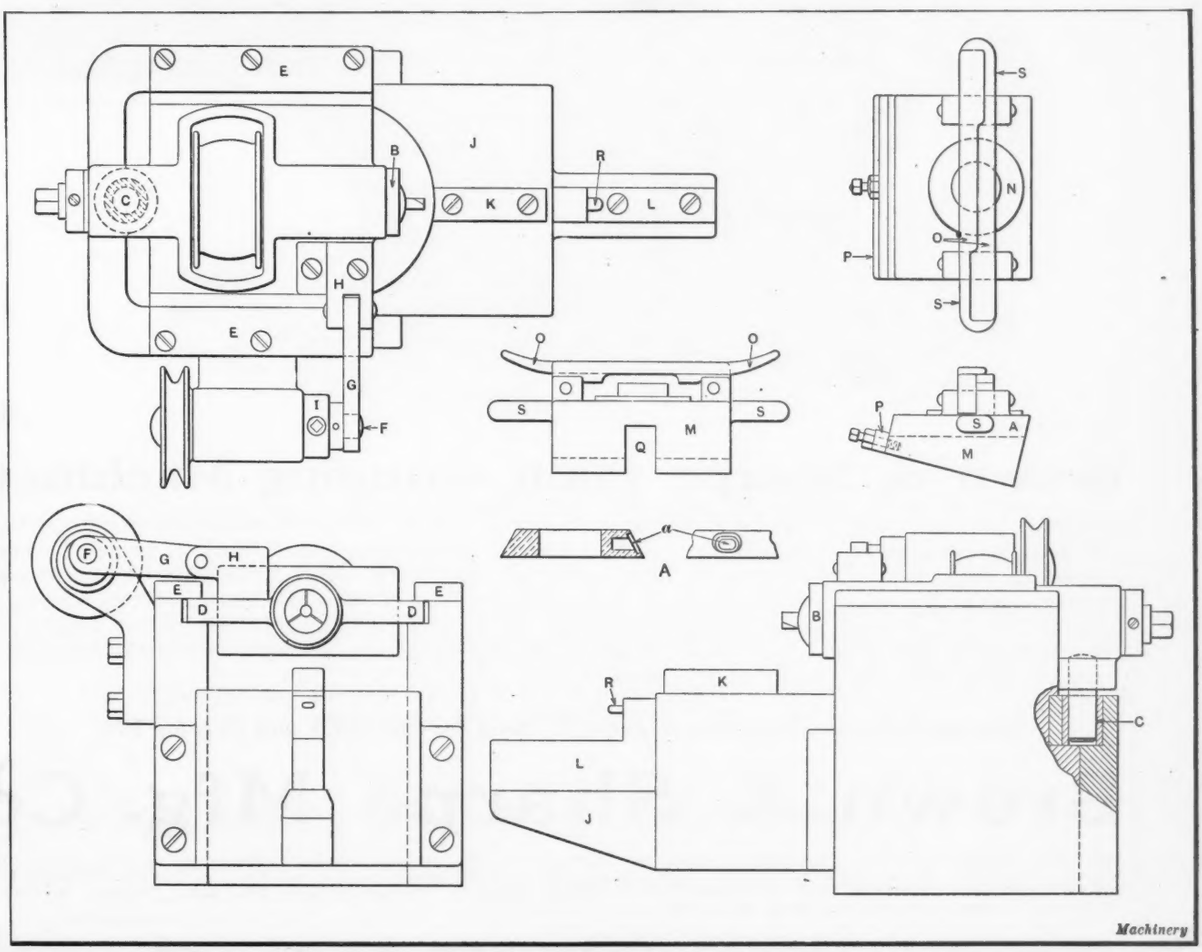
The jig consists of a cast-iron base *M* shaped as shown. It rests on a knee *J* and is adjusted sidewise by strip *K*. The jig slides on strip *L* when the work is being located. On the top face of the jig is a hardened and ground nose-piece and plate *N* for locating the ring; two finger-levers *O* clamp the work to the jig. A screw passing through a bar *P* across the back end of the jig adjusts for the proper depth of disk seat, bearing against the end of the locating piece *K*.

In operation, the jig is first located on strip *L*, which is made a slide fit in the slot *Q* in the base of the jig. Next a ring is put on over the locating nose *N*, the finger-levers *O* are dropped down over the ring, but no pressure is applied, the jig is pushed forward until the locating pin *R* enters the flash hole, which was made in a previous operation. This locates the ring in the proper position on the jig. Then the finger-levers *O* are held down tightly on the work while the jig is grasped by lugs *S* and placed on strip *K*. It is then slid forward until the oscillating cutter finishes the hole.

The work of the machine is practically perfect, and a production of 2500 to 3000 a day can be maintained. The spindle should run at a speed of not less than 6000 revolutions per minute. The cutters best suited for this work are the usual type of straight-fluted end-mills; six flutes give the best results. Their only difference from the commercial end-mill is that the end teeth have more clearance.

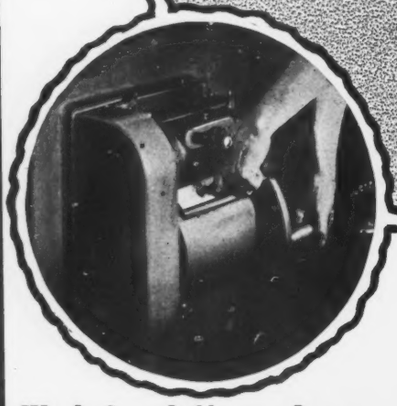
* * *

President Wilson has approved an agreement between the War Industries Board and steel manufacturers fixing the following prices, which become effective immediately and are subject to revision January 1, 1918: steel plates, $65 per ton; steel shapes, $60 per ton; steel bars, $58 per ton; pig iron, $33 per gross ton; and iron ore, $5.05 per gross ton. These prices are for the United States government, its allies and the public, after existing contracts expire, and represent reductions of from 43 to 70 per cent. This announcement is in line with fixing the price of wheat at $2.20 per bushel, bituminous coal at $2 per ton, and copper at 23.5 cents per pound.



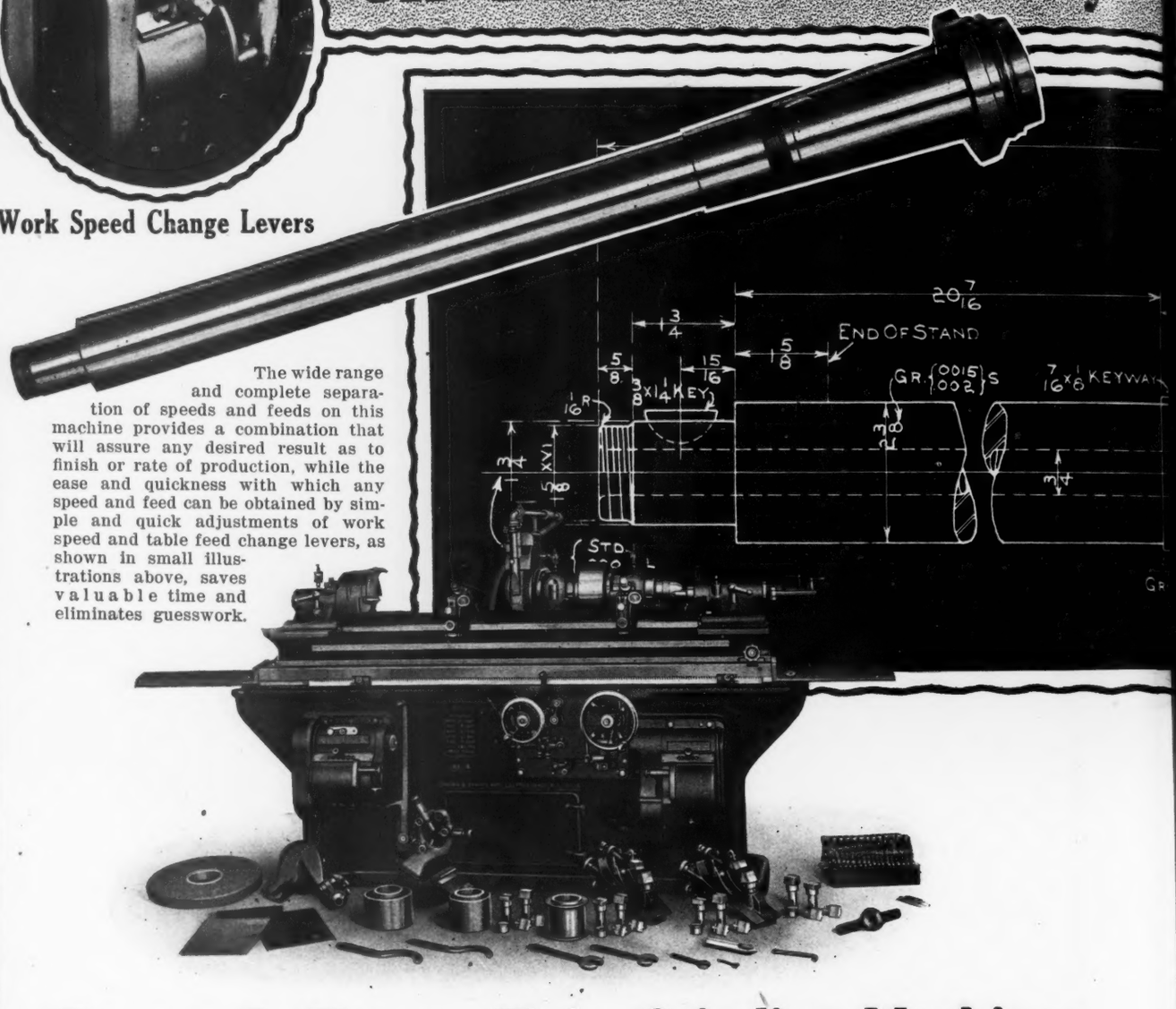
Jig and Machine for recessing Time-ring Disk Seats

Correct Speed and Feed on This Piece Easily



Work Speed Change Levers

The wide range and complete separation of speeds and feeds on this machine provides a combination that will assure any desired result as to finish or rate of production, while the ease and quickness with which any speed and feed can be obtained by simple and quick adjustments of work speed and table feed change levers, as shown in small illustrations above, saves valuable time and eliminates guesswork.



Brown & Sharpe Plain Grinding Machines

fulfill the various conditions to be met with in handling a wide variety of cylindrical grinding in a way that instantly appeals to both the operator and the production man. Work of large or small diameter, work which includes both large andsmall diameters, such as the piece shown above, or long slender pieces are all the same to the operator of one of these machines as far as accuracy and fast production are concerned. The wide range, complete separation and ease and quickness of obtaining work speeds and table feeds, while especially important, are but a few of the many features of these accurate and rapid machines.

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Feed for Diameters and Quickly Obtained

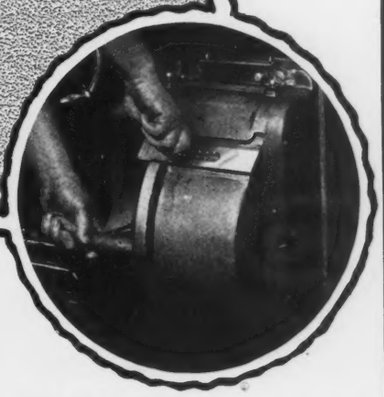
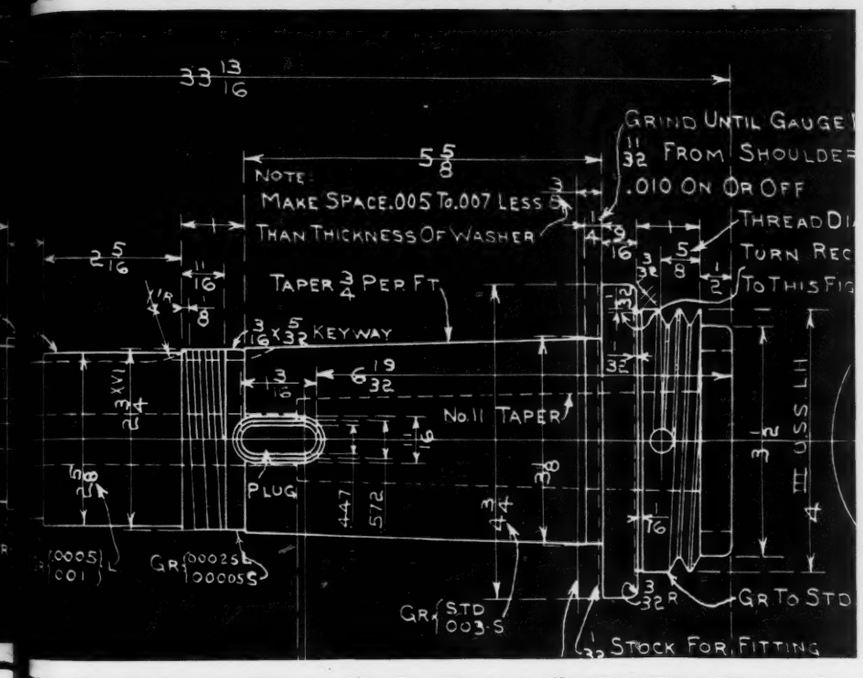


Table Feed Change Levers



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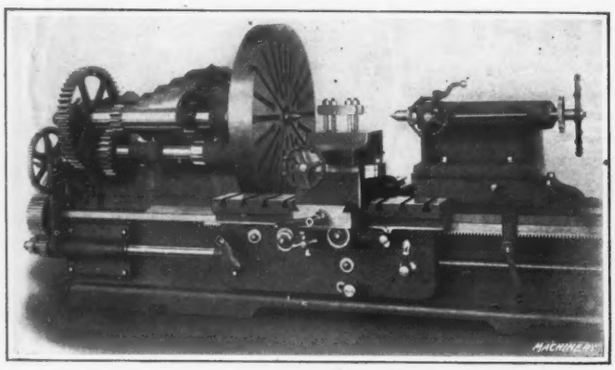
DAVID A. WRIGHT BUILDING FIFIELD LATHES

David A. Wright, 568 W. Washington Blvd., Chicago, Ill., has taken over the manufacturing rights on the heavy-duty engine lathes formerly built by George W. Fifield, Lowell, Mass. In addition to the manufacturing rights, Mr. Wright has acquired the patterns, jigs, fixtures and other equipment



Fifield Heavy-duty Engine Lathe now built by David A. Wright

of a similar nature used in the manufacture of these machines. He is building lathes with 34-, 40-, 50-, 60-, 72-, 84- and 96-inch swing.

* * *

U. S. INSPECTORS FOR ORDNANCE EQUIPMENT

An examination for inspectors of ordnance equipment has been announced by the Civil Service Commission. One class of this examination is for inspectors of hardware and metal equipment, comprising such articles as buckles, rings, fasteners, hand axes, wire cutters, intrenching tools, canteens, cups, meat cans, cutlery and other small articles of brass, iron, steel or aluminum. Men who have had a high school or equivalent education, and in addition four years experience in a manufacturing plant making such articles as those listed, will qualify for one class of inspectors. Another class of inspectors requires men over twenty-five years of age who are graduates from a college or university of recognized standing and who have had one year's experience in a manufacturing plant on the practical end of the work. The duties of inspectors will consist in the organization and supervision of the inspection work in plants where equipment as described above is being manufactured. They will also be responsible for the preparation of the necessary reports covering the inspection, shipment and payment. The positions will be civil service appointments, and the salaries range from $1200 to $2400 a year with allowances for traveling expenses. Further information can be obtained from the Equipment Division, Inspection Section, 1330 F St., N.W., Washington, D. C., or from any office of the United States Civil Service Commission.

* * *

THE MODERN METHODS SCHOOL

Eugene C. Peck, general superintendent of the Cleveland Twist Drill Co., Cleveland, Ohio, long felt the need for trained factory workers, and some years ago started a night school in which his men were instructed in elementary mathematics and other common subjects. He compiled a series of lesson papers that were used with much satisfaction. Some of Mr. Peck's friends conceived the idea of collecting and compiling these papers, and as the result the Modern Methods School Co. was started about a year ago in Cleveland, and now has over 400 factory employes as students studying the Peck booklets.

The school gives a practical course on efficient factory management by correspondence. This is a course that starts with the workman and ends with the factory manager, and is invaluable to the workmen and the executives, as it teaches them to become better and more efficient workmen, foremen, assistant superintendents, purchasing agents, engineers, etc. To the man who has fully developed himself in his trade or profession it is especially useful, as it not only tends to help him in his present work, but prepares him for the position ahead, so that he is thoroughly acquainted with all phases of his new position when the opportunity for advancement arrives.

Mr. Peck, the president of the school and the author of the course, is a man who has had many years' experience as a practical and successful factory manager. All the other officers and members of the faculty are men who have had practical experience in the various courses that they teach, and are fitted as instructors. There is also an advisory board connected with the school, the members of which are practical and successful executives of many of the well-known business enterprises of the country. Any problem coming up in the daily work of the student may be submitted to these men with the assurance of receiving helpful and practical advice on the matter.

* * *

TUNGSTENLESS HIGH-SPEED STEEL

Darwin & Milner, of Sheffield, England, have announced the discovery of a new high-speed steel containing no tungsten, which is said to be equal in durability and hardness to the best high-speed steel containing tungsten. The new steel, called "Cobaltcrom," is suitable for milling cutters, twist drills, reamers, taps, automatic forming tools, screw cutting and finishing tools in general, being guaranteed to give endurance equal to the best tungsten high-speed steel. It is claimed that the "Cobaltcrom" tools produce a better finish and are tougher than those made of tungsten steel. Another valuable quality claimed for the tungstenless steel is the complete absence of cracking risks in hardening the most intricate shaped tools. Shrinkage and deformation during the hardening are practically nil, and the saving in rectification costs alone becomes an important item. The specific gravity of the new tool steel is about 10 per cent less than that of tungsten high-speed steel, which means that, taking weight for weight, a greater bulk of material is obtained, thus resulting in an appreciable gain to the user. Tungsten high-speed steel requires a temperature of 1250 to 1350 degrees C. (2282 to 2462 degrees F.) for hardening, while "Cobaltcrom" is hardened at 1000 degrees C. (1832 degrees F.). Owing to the embargo placed by the British government on the exportation of high-speed steel, the American agent, Darwin & Milner, Inc., New York City, is able to furnish only a limited amount to American customers at present.

* * *

COMPLETION OF THE QUEBEC BRIDGE

During the third week in September, the last span of the Quebec bridge was put into place. When open, this bridge will carry the traffic of eight railroads across the St. Lawrence River and will reduce the rail distance between Halifax and western Canada 200 miles. On September 17, the central span, which is 640 feet long and the keystone of the structure, was floated down to the bridge site on scows and fastened in place. When the scows were removed, the 5000-ton mass was raised in two-foot stages and that night swung twenty-eight feet above the position from which it was started upward. It was raised forty-two feet the next day, and reached its final position on September 20.

Profiting by the disaster of last year, the engineers used all possible precautions against a recurrence. The care with which the calculations have been made can be realized from the fact that the 5000-ton mass of metal varied only five-eighths inch from the computations as to how far it would bring down the cantilevers after the scows had floated from beneath it. After each hoist, the mooring trusses, which ultimately will hold the span in place, were attached in order to hold it still until the jacks were made ready for a new upward thrust. The span was raised in two-foot stages, instead of the three-foot stages used the year before, and on September 19, when the span had reached the middle of its 150-foot ascent, the speed of hoisting was reduced from two feet in eleven minutes to two feet in fourteen minutes. In 1907 a structure of nearly the same magnitude collapsed, causing the loss of seventy lives.